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CDM 2.0 (Climatological Dispersion Model Version 2.0) User's Guide

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CDM 2.0 -- CLIMATOLOGICAL DISPERSION MODEL

User's Guide

by

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CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) quasi-stable pollutant concentrations in rural or urban settings using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The Gaussian plume hypothesis forms the basis for the calculations. Contributions are calculated assuming the narrow plume hypothesis, Calder (1971, 1977), and involve an upwind integration over the area sources. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations. The number of point and area souces can be easily modified within the code. CDM-2.0 is an enhanced version of CDM including the following options: 16 or 36 wind-direction sectors, initial plume dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual (transitional) plume rise. The user has a choice of seven dispersion parameter schemes. Optional output includes point and area concentration roses and histograms of pollutant concentration by stability class.

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FOREWORD

The Atmospheric Sciences Research Laboratory conducts a research program in the physical sciences to detect, define, and quantify the effects of air pollution on urban, regional, and global atmospheres and the subsequent impact on water quality and land use. This includes research and development programs designed to quantify the relationships between emissions of pollutants from all types of sources and air quality and atmospheric effects.

The Meteorology and Assessment Division conducts research programs in environmental meteorology to describe the roles and interrelationships of atmospheric processes and airborne pollutants in effective air and land resource management. Developed air quality simulation models are made available to dispersion model users in computer-readable form (magnetic tape media) from NTIS (see preface).

CDM-2.0 is an enhanced version of CDM. The following options have been added to the original CDM algorithm: 16 or 36 wind-direction sectors, initial dispersion, buoyancy-induced dispersion, stack downwash, and gradual plume rise. In addition, the user has a choice of seven dispersion parameter schemes. The output format has been modified to enhance readability. Concentration versus stability histograms have been added to an output option.

Limitations are imposed on the use of the program by the assumption that pollutants are nonreactive and that one wind vector and stability class are representative of the area being modeled. Despite these limitations, CDM-2.0 is a useful long-term (seasonal or annual) algorithm for estimating nonreactive pollutant concentrations from point and area sources in a rural or urban setting.

A. H. Ellison
Director
Atmospheric Sciences Research Laboratory

PREFACE

One area of research within the Meteorology and Assessment Division is development, evaluation, validation, and application of models for air quality simulation, photochemistry, and meteorology. The models must be able to describe air quality and atmospheric processes affecting the dispersion of airborne pollutants on scales ranging from local to global. Within the Division, the Environmental Operations Branch adapts and evaluates new and existing meteorological dispersion models and statistical technique models, tailors effective models for recurring user application, and makes these models available through EPA's User's Network for Applied Modeling of Air Pollution (UNAMAP) system.

CDM-2.0 estimates long-term nonreactive pollutant concentrations using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability.

Although attempts are made to thoroughly check computer programs with a wide variety of input data, errors are occasionally found. Revisions may be obtained as they are issued by completing and returning the form on the last page of this guide.

The first four sections of this document are directed to managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 5, 6, and 10 are directed to engineers, meteorologists, and other scientists who are required to become familiar with the details of the model. Finally, Sections 7 through 10 are directed to persons responsible for implementing and executing the program.

Comments and suggestions regarding this publication should be directed to:

Chief, Environmental Operations Branch
Meteorology and Assessment Division (MD-80)
Environmental Protection Agency
Research Triangle Park, NC 27711.

Technical questions regarding use of the model may be asked by calling (919) 541-4564. Users within the Federal Government may call FTS 629-4564. Copies of the user's guide are available from the National Technical Information Service (NTIS), Springfield, VA 22161.

The next release of UNAMAP (Version 6) will include the code for CDM-2.0. Inquiries regarding the purchase of UNAMAP should be addressed to Computer Products, NTIS, Springfield, VA 22161 (phone number: 703-487-4763).

ABSTRACT

CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) quasi-stable pollutant concentrations in rural or urban settings using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The Gaussian plume hypothesis forms the basis for the calculations. Contributions are calculated assuming the narrow plume hypothesis, Calder (1971, 1977), and involve an upwind integration over the area sources. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations. The number of point and area sources can be easily modified within the code. CDM-2.0 is an enhanced version of CDM including the following options: 16 or 36 wind-direction sectors, initial plume dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual (transitional) plume rise. The user has a choice of seven dispersion parameter schemes. Optional output includes point and area concentration roses and histograms of pollutant concentration by stability class.

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SYMBOLS AND ABBREVIATIONS

Dimensions are abbreviated as follows:
m = mass, l = length, t = time, K = temperature

a, b, c = constants in dispersion parameter equations
A, B = calibration constants (i.e., intercept and slope, respectively)
$\bar{C}_A$ = average concentration from area sources (m/l^3)
$\bar{C}_P$ = average concentration from point sources (m/l^3)
D_s = stack inside diameter (l)
f = stack-tip downwash correction factor
f_e = fraction of the input area source height that represents the physical height
F = buoyancy flux parameter (l^4/t^3)
Fr = Froude number
g = acceleration due to gravity (l/t^2)
G_n = emission rate of nth point source (m/t)
h = physical stack height (l)
h' = stack height adjusted for Briggs stack-tip downwash (l)
H = effective stack height (l)
H_a = input area source height (physical height plus assumed effluent rise with a 5 m/sec wind speed) (l)
k = index identifying the wind-direction sector
k_n = wind sector appropriate for nth point source
ℓ = index identifying the wind-speed class
L = mixing height (l)
m = index identifying the stability category
n = number of point sources
N = number of wind-direction sectors
p = wind-profile exponent

SYMBOLS AND ABBREVIATIONS (continued)

p_a = atmospheric pressure (m/lt^2)
P_m = stability class
$Q(\rho,\theta)$ = area source emission rate per unit area (m/tl^2)
$q_k(\rho)$ = $\int Q(\rho,\theta)d\theta$ (m/t)
s = stability parameter (t^{-2})
$S(\rho,z;U_\ell,P_m)$ = dispersion function
$T_{1/2}$ = pollutant half-life (t)
T_a = ambient air temperature (K)
T_s = stack gas exit temperature (K)
U = wind speed at stack height (l/t)
U_ℓ = representative wind speed (l/t)
V_s = stack gas exit velocity (l/t)
x_f = distance to final rise (l)
x^* = distance at which atmospheric turbulence begins to dominate entrainment (l)
X, Y = axes of the grid system; X-axis points east and Y-axis points north
z = height of receptor above ground level (l)
ΔH = plume rise (l)
$\partial\theta/\partial z$ = vertical potential temperature gradient of a layer of air (K/l)
θ = angle relative to polar coordinates centered on receptor (radians)
ρ = distance from receptor to source (l)
ρ_n = distance from receptor to nth point source (l)
σ_z = vertical dispersion parameter (l)
σ_{zb} = buoyancy-induced vertical dispersion (l)
σ_{ze} = effective vertical dispersion (l)
$\phi(k,\ell,m)$ = meteorological joint frequency function

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Support of Aerocomp by the Environmental Protection Agency Contract Nos. 68-02-3750 and 68-02-4106 is also gratefully acknowledged.

EXECUTIVE SUMMARY

CDM-2.0 (Climatological Dispersion Model - Version 2.0) determines long-term (seasonal or annual) pollutant concentrations in a rural or urban setting using average emission rates from point and area sources and a joint frequency distribution of wind direction, wind speed, and stability. The algorithm is based on Gaussian plume assumptions and is thus subject to the limitations of nonreactive pollutants and a homogeneous wind field. Computations can be made for up to 200 point sources and 2500 area sources at an unlimited number of receptor locations.

CDM-2.0 is an enhanced version of CDM. The enhancements of CDM-2.0 give the user added flexibility to tailor technical features of the model to particular source-receptor configurations and locales. The joint-frequency function describing the meteorology can be specified using either a 16-point or a 36-point compass for the wind sectors. The initial dispersion for point sources can be computed as either a building effect (affecting dispersion from sources with stack heights below 50 m) as a buoyant plume rise effect (described by Pasquill, 1976), or both. Provision has been made to allow estimation of the effects of stack downwash on the plume rise using either of two algorithms -- Briggs (1974) or Bjorklund and Bowers (1982). The user has the option of choosing among seven schemes for characterizing vertical dispersion downwind of the source. Added to the dispersion algorithm used by CDM (Busse and Zimmerman, 1973) are the following schemes:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),

- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The former versions of CDM "slipped" the categories to account for urban effects on the dispersion. The inclusion of the various dispersion characterizations provides the user with both urban and rural dispersion schemes. The specific curve to be applied to each of the input frequency function stability categories is user controlled. The user specifies the initial dispersion for each stability category for use in the area source computations. The user specifies the power-law exponent and the central wind speed values to be employed for each stability category. Provision is made to model pollutant removal by physical or chemical processes by a half-life decay that is user specified. Plume rise for the point sources can be calculated following the methods of Briggs (1969, 1971, and 1975) or using the methods of Holland (1953). Provision has been made to allow estimation of the effects of wind speed variation on the area-source effective release height as described by Turner and Novak (1978). The output format has been modified to enhance readability. Concentration versus stability histograms have been added as an output option.

The source code has been designed so that future enhancements can be readily implemented. For instance, the number of sources considered by the model can be modified by a global change within the code. Also, other dispersion schemes can be added to subroutine SIGMAZ with little difficulty.

SECTION 1

INTRODUCTION

CDM-2.0 is an enhanced version of CDM (Version 80247) affording the user increased control of the technical features to be employed in each modeling analysis. The user now controls the specification of the wind profile power-law exponents, the central wind speed values, the dispersion curves, and the mixing heights to be associated with each stability category. These were formerly defined by DATA statements in CDM and beyond user control. The plume rise algorithm has been modified to handle rise during stable conditions and to consider momentum-dominated plumes. Stack downwash can be modeled using either of two schemes -- Briggs (1974) or Bjorklund and Bowers (1982). Initial dispersion can be modeled as (1) a building effect, affecting sources with stack heights below 50 m, (2) as a buoyant plume-rise effect, as described by Pasquill (1976), or (3) joint building and buoyant rise effects. The user has the option of choosing among seven schemes for characterizing vertical dispersion downwind of the source. The output format has been modified to enchance readability and the concentration versus stability histogram has been added as an output option.

The Gaussian plume hypothesis is the basis for CDM-2.0. Pasquill and Meade (1958) first modified the Gaussian plume equation to estimate long-term average concentrations from a particular source using a wind direction frequency distribution. Expanding on Pasquill and Meade's initial work, Martin and Tikvart (TRW Systems Group, 1969; Martin and Tikvart, 1968; and Martin, 1971) developed AQDM (Air Quality Display Model). In their methodology, the frequency of occurrence of various possible combinations of wind direction, wind speed, and atmospheric stability are used to obtain long-term average concentrations from a multiple source grid. Calder (1971, 1977) formulated a model called CDM (Climatological Dispersion Model) which eventually superseded AQDM. Although similiar to AQDM in many respects, CDM has several distinct features. AQDM treats area sources via a modified virtual point source technique. In CDM, contributions from area sources are calculated by assuming the narrow plume hypothesis (Calder, 1971, 1977) and involve an upwind integration over the area sources. Holland's plume rise equation (Holland, 1953) is used in AQDM, while in CDM the user has a choice between Briggs' plume rise (Briggs, 1971) or Holland's equation. A power-law profile is used in CDM to extrapolate surface wind speeds to the source height. AQDM and CDM were two of six air quality dispersion models used to calculate annual (1969) sulfur dioxide and total suspended particulate matter for the New York Air Quality Control Region (Turner et al., 1972). Model-predicted concentrations were compared statistically with the measured values. The results indicate that CDM performed better than AQDM (i.e., errors in the means and maxima were smaller for CDM).

This document is divided into three parts, each directed to a different reader: managers, dispersion meteorologists, and computer specialists. The first four sections are aimed at managers and project directors who wish to evaluate the applicability of the model to their needs. Sections 5, 6, and 10 are directed toward dispersion meteorologists or engineers who are required to become familiar with the details of the model. Finally, Sections 7 through 10 are directed toward persons responsible for implementing and executing the program. An example of model execution with the default option is given in Appendix A; detailed program flow diagrams and a listing of the FORTRAN source statements are given in Appendices B and C respectively.

SECTION 2

DATA-REQUIREMENTS CHECKLIST

CDM-2.0 requires data on user options, grid dimensions, sources, meteorology, receptors, and model calibration constants. The user must indicate whether the following options are to be employed for point source calculations:

- Initial dispersion and/or buoyancy-induced dispersion,
- Stack-tip downwash, and
- Gradual plume rise.

Also to be indicated is whether the stability array data is divided into 16 or 36 wind-direction sectors. Additionally, there is a choice of one of seven dispersion schemes. Output options include area and point source concentration roses and concentration versus stability histograms at selected receptors.

Information required for each source includes the following:

- Location (user units),
- Area-source side length (m)
- Average emission rate (g/sec) for both pollutants,
- Daytime and nighttime emission rate ratios,
- Source height (m),
- Stack diameter (m),
- Stack gas exit velocity (m/sec),
- Stack gas temperature (°F, °C, or K), and
- Decay half-life (hr).

Area-source side length is required for area sources; stack diameter, exit velocity, and exit temperature are pertinent to point sources only.

Meteorological data needed for the computations are:

- Joint frequency function of wind direction, wind speed, and stability category,
- Average wind speed (m/sec) representing each of six wind-speed categories,
- Mean atmospheric temperature (°C),
- Mixing heights (m) for each of six stability classes, and
- Wind-profile exponents for each stability class.

The user has the option of inputting a joint frequency function based on 16 or 36 wind-direction sectors. The first wind sector of the joint frequency function must be centered on the wind direction azimuth of 0°.

The location of each receptor must be indicated. If available, the observed concentration of each pollutant can be supplied. Also the user has the option of specifying the height above ground (m) of all the receptors.

Calibration constants based on previous CDM-2.0 runs and on observed data can be provided and used to obtain adjusted concentration values.

SECTION 3

FEATURES AND LIMITATIONS

As noted previously, CDM-2.0 is an upgraded version of program CDM which was released in 1973. CDM-2.0 is a long-term (seasonal or annual) algorithm for evaluating the effects of multiple point and area sources in the near-field (within 25 km). The modeling region should consist of relatively flat terrain. The model includes the following computation features in common with CDM:

- Can handle up to 200 point sources and 2500 area sources,
- Unlimited number of receptors can be considered, and
- Optional use of Holland's equation (1953) for limiting plume rise.

It should be noted that the number of sources can be modified by a global change within the code. Optional output features common to both CDM and CDM-2.0 are point and area concentration roses at a set of user-specified receptors. The user can reduce output volume by just listing concentration results and not echoing the input data.

Modeling features added to CDM-2.0 include:

- Optional initial dispersion, buoyancy-induced dispersion, stack-tip downwash, and gradual plume rise;
- Choice of joint frequency function based on 16 or 36 wind direction sectors;
- Choice of one of seven dispersion parameter schemes; and
- Optional output of concentration versus stability histograms at user-specified receptors.

The plume rise algorithm has been modified to handle rise during stable conditions and to consider momentum-dominated plumes.

Its limitations are as follows:

- Source emissions and meteorology should be uncorrelated,
- Variation in emission rate between adjacent area sources is assumed to be negligible,
- Terrain should be flat to gently rolling, and
- No consideration of chemical reactions or removal other than that which can be handled as a simple exponential decay.

It is assumed that one wind vector and one stability category are representative at any given time of the area being modeled.

Table 1 compares CDM-2.0 features to those of other long-term air quality models.

TABLE 1. A COMPARISON OF CDM-2.0 TO OTHER COMMONLY USED LONG-TERM AIR QUALITY MODELS.

X - used by model O - optional	CDM-2.0	MPTER	CRSTER	VALLEY	ISC	CDM
MODEL TYPE						
Gaussian	X	X	X	X	X	X
Other						
AVERAGING PERIOD						
Hour		O	X		O	
3-hour		O	X		O	
24-hour		O	X	O	O	
Annual	X	O	X	O	O	X
TYPE OF SOURCES						
Single stack	X	X	X	X	X	X
Multiple stacks	200	250	19[1]	50[2]	X[3]	200
Area sources	2500			50[2]	X[3]	2500
Line sources						
RECEPTORS						
Number of receptors	X[4]	180	180	112	360	X[4]
Cartesian coordinates		X				X
Cartesian coordinates w/ elevations	X	X			X	
Polar coordinates		X				
Polar coordinates w/ elevations		X	X	X	X	
Program generated grid						
METEOROLOGICAL DATA						
RAMMET preprocessor		X	X		X	
STAR file	X			X	X	X
User specified	X	O		X	O	X
POLLUTANT						
Non-reactive	X	X	X	X	X[5]	X
Half-life	O	O		O	O	O
PLUME RISE						
Stack-tip downwash	O	O	O		O	
Gradual plume rise	O	O	O	O	O	X
Buoyancy-induced dispersion	O	O		O		
TERRAIN ADJUSTMENTS		O	O	O	O	

(1) Co-located stacks.
(2) Total of 50 point and/or area sources.
(3) Number of sources depends upon several input parameters.
(4) Unlimited.
(5) Gravitational settling and dry deposition considered.

SECTION 4

BASIS FOR CDM-2.0

This section presents a brief narrative highlighting important aspects of the modeling approach. A detailed technical description, including equations, is provided in Section 5.

GAUSSIAN PLUME ORIGINS

CDM-2.0 is based upon the Gaussian plume hypothesis. Gaussian plume methodology assumes that pollutant concentrations from a continuously emitted plume are proportional to the emission rate, and are diluted by the wind at the point of emission at a rate inversely proportional to the wind speed. It is also assumed that the pollutant concentrations in the vertical near the source are closely described by Gaussian or normal distributions. Calder (1971, 1977) showed that under the special circumstance when emissions and meteorology can be treated as statistically independent, i. e., uncorrelated, that the long-term average concentration values can be estimated using the average emission values and the joint frequency function of meteorological conditions. In the methodology, the joint frequency function is assumed to be piece-wise constant in 22.5° (10°) wind sectors of a 16-point (36-point) compass. We assume that in practice (and certainly when large grid areas are used to specify the area-source emissions), the variations in emission rates between adjacent area sources can be disregarded. Then under the narrow plume hypothesis, the equations for computing the long-term average concentration contributions from the point sources and the area sources do not involve the crosswind dispersion parameter, but only the vertical dispersion parameter. The area-source contributions are determined by an integration over the upwind area sources. For this integration, an area-source emission rate (over the wind-sector width) is determined at various distances upwind from each receptor.

PLUME RISE

The user can choose between two methods of estimating plume rise: Briggs' plume rise (1969, 1971, and 1975) and Holland's equation (1953). The Briggs formulation treats both buoyancy-dominated and momentum-dominated rise. In Holland's equation, the value of the product of the average wind speed and the height of plume rise is used. This option permits no variation of the product with distance from the stack and the magnitude of the plume rise is at the discretion of the user.

DISPERSION ALGORITHMS

As an option the user can choose one of seven schemes for characterizing vertical dispersion downwind of the source. These include the following:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),
- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977),
- PGCDM (Busse and Zimmerman, 1973), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The above algorithms are functions of downwind distance and atmospheric stability. Dispersion curves and equations for each of the schemes are presented in the next section.

SECTION 5

TECHNICAL DESCRIPTION

This section expands on concepts mentioned briefly in Section 4. The mathematical formulation of the physical processes simulated by CDM-2.0 are presented here. Equations are shown in their final form (i.e., without derivations); however, references are provided for those readers interested in details.

METEOROLOGICAL PARAMETERS

Joint Frequency Function

The joint frequency function (also known as STability ARray) is required as input for the model. This function gives the joint frequency of occurrence of a wind-direction sector, a wind-speed class, and a stability category index. The user has the option of providing a joint frequency function based on 16 wind-direction sectors (each sector is 22.5°) or 36 sectors (each sector is 10°). It is required that the first wind sector be centered on the wind direction azimuth of 0°. There are 576 entries in the joint frequency function table for 16 wind-direction sectors (i.e., 16 wind-direction sectors, 6 wind-speed classes, and 6 stability classes). If the user's joint frequency function is based on a 36 point wind rose, then there are 1296 entries in the table.

The relationship between the Pasquill stability classes and those used in CDM-2.0 is shown in Table 2.

TABLE 2. RELATIONSHIP BETWEEN PASQUILL STABILITY CLASSES AND THOSE USED IN CDM-2.0

Pasquill stability class	CDM-2.0 stability index
A	1
B	2
C	3
D, day	4
D, night	5
E	6
F	7

The seven classes result from neutral stability being separated into daytime and nighttime conditions. Although CDM-2.0 recognizes 7 distinct categories, the joint frequency function is assumed to be comprised of only 6 stability classes. The user indicates the dispersion curve associated with each of the stability categories of his joint frequency data via variables ICP and ICA. These and other input parameters are described in Section 8.

The user must supply the central wind speed for each of the six speed categories; typically that is the harmonic average wind speed. Wind speed intervals assumed in the National Climatic Center (NCC) STAR summaries are shown in Table 3, along with appropriate central wind speeds.

TABLE 3. NCC STAR SPEED INTERVALS AND CENTRAL WIND SPEEDS

Wind speed class	NCC speed interval (knots)	Central wind speeds (m/sec)
1	0 to 3	1.50 *
2	4 to 6	2.46
3	7 to 10	4.47
4	11 to 16	6.93
5	17 to 21	9.61
6	> 21	12.52

* Light winds reported in the first wind speed class are rounded up to 1.50 m/sec. Operational wind instruments are designed for durability and also to withstand exposure to strong, gusty airflow. For these reasons, most wind sensors have a high starting speed, which can lead to the erroneous reporting of light winds as calms (Truppi, 1968).

Wind Profile

Wind speed generally increases with height above the surface, and this increase depends on both surface roughness and atmospheric stability. A power-law profile of the form

$$U(z) = U_{\ell}(z/10)^{p} \tag{1}$$

is used by CDM-2.0 to approximate this increase. The wind speed at a height z above the ground is U(z); U_{ℓ} is the wind speed measured at the anemometer height (10 m above the ground); and p is a function of stability. The user supplies the wind-profile exponents, p, for each stability class. Suggested wind-profile exponents are shown in Table 4. For a more detailed discussion of wind profiles, the reader may refer to Irwin (1979).

TABLE 4. WIND PROFILE EXPONENTS FOR TWO SURFACE ROUGHNESSES

	Stability class					
	A	B	C	D	E	F
Urban p	0.15	0.15	0.20	0.25	0.30	0.30
Rural p	0.07	0.07	0.10	0.15	0.35	0.55

Mixing Height

The magnitude of the mixing height undergoes considerable diurnal, seasonal, and annual variation. It is impractical to account for all such variations in detail. Some recognition is given to changes in the magnitude of the mixing height by assigning an appropriate value to each stability category. The user must choose an appropriate relationship between mixing height and stability category. One possible parameterization is given in Table 5.

TABLE 5. MIXING HEIGHTS BASED ON STABILITY CATEGORY

Stability category	Mixing height, meters
A	$3\bar{L}/2$
B	$\bar{L}$
C	$\bar{L}$
D, day	$\bar{L}$
D, night	$(\bar{L} + L_{min})/2$
E - F	L_{min}

In Table 5, $\bar{L}$ is the climatological mean value of the mixing height as tabulated by Holzworth (1972) and L_{min} is the nocturnal mixing height.

CONCENTRATION FORMULAS

The average concentration due to area sources, C , at a particular receptor is given by

$$\bar{C}_A = (N/2\pi) \int_0^\infty [\sum_{k=1}^{N} q_k(\rho) \sum_{\ell=1}^{6} \sum_{m=1}^{6} \phi(k,\ell,m)\, S(\rho,z;U_\ell,P_m)]\, d\rho, \qquad (2)$$

where,

N = number of wind-direction sectors (i.e., 16 or 36),

k = index identifying wind-direction sector,

$q_k(\rho)$ = $\int Q(\rho,\theta)d\theta$ for the k sector,

$Q(\rho,\theta)$ = emission rate of the area source per unit area,

ρ = distance from the receptor to an infinitesimal area source,
θ = angle relative to polar coordinates centered on the receptor,
ℓ = index identifying the wind-speed class,
m = index identifying the stability category,
$\phi(k,\ell,m)$ = joint frequency function,
$S(\rho,z;U_\ell,P_m)$ = dispersion function defined in Eqs. 4 and 5,
z = height of receptor above ground level,
U_ℓ = representative wind speed,
P_m = stability category.

For point sources, the average concentration due to n point sources, $\bar{C}_\rho$, is given by

$$\bar{C}_\rho = (N/2\pi) \sum_{n=1}^{n} \sum_{\ell=1}^{6} \sum_{m=1}^{6} [\phi(k_n,\ell,m)\ G_n\ S(\rho_n,z;U_\ell,P_m)]/\rho_n , \qquad (3)$$

where
k_n = wind sector appropriate to the nth point source,
G_n = emission rate of the nth point source,
ρ_n = distance from the receptor to the nth point source.

The dispersion function, $S(\rho,z,;U_\ell,P_m)$, is defined as

$$S(\rho,z;U_\ell,P_m) = 2/(\sqrt{2\pi}U_\ell \sigma_z)\Big[\exp\{-(1/2)[(z-H)/\sigma_z]^2\} + \exp\{-(1/2)[(z+H)/\sigma_z]^2\}\Big]\exp[-0.692\rho/(U_\ell T_{1/2})], \qquad (4)$$

if $\sigma_z < 0.8L$ and as

$$S(\rho,z;U_\ell,P_m) = (1/U_\ell L)\exp[-0.692\rho/(U_\ell T_{1/2})], \qquad (5)$$

if $\sigma_z > 0.8L$. New terms in Eqs. 4 and 5 are defined as follows:

σ_z = vertical dispersion parameter, i.e., the standard deviation of the pollutant concentration in the vertical plane, H = effective stack height of source distribution, i.e., the average height of area source emissions in the kth wind direction sector at radial distance ρ from the receptor,

L = the mixing height,

$T_{1/2}$ = assumed half-life of pollutant (hr).

The possibility of pollutant removal by physical or chemical processes is included in the program by the decay expression, $\exp[-0.692\rho/(U_{\ell}T_{1/2})]$. The total concentration for the averaging period is the sum of concentrations of the point and area sources for that averaging period.

Computational procedures for area source contributions differ among the sector-average models in UNAMAP. For instance, Valley and ISCLT consider area sources as virtual point sources (Burt, 1977; Bowers et al., 1979). This computational method differs from the procedure used in CDM-2.0, which is discussed next.

Suppose that receptor R is located within the grid array as shown in Figure 1a. The first step in the program is to determine the distance from the receptor to the farthest corner of the grid array. This distance, ρ_M, is taken as the upper limit of the integral $q_k(\rho)$ in Eq. 2.

An angular integration, using the trapezoidal rule, is carried out numerically, as shown in the blow-up in Figure 1b. This integration determines $q_k(\rho)$ at various increments of ρ, as indicated in Table 6.

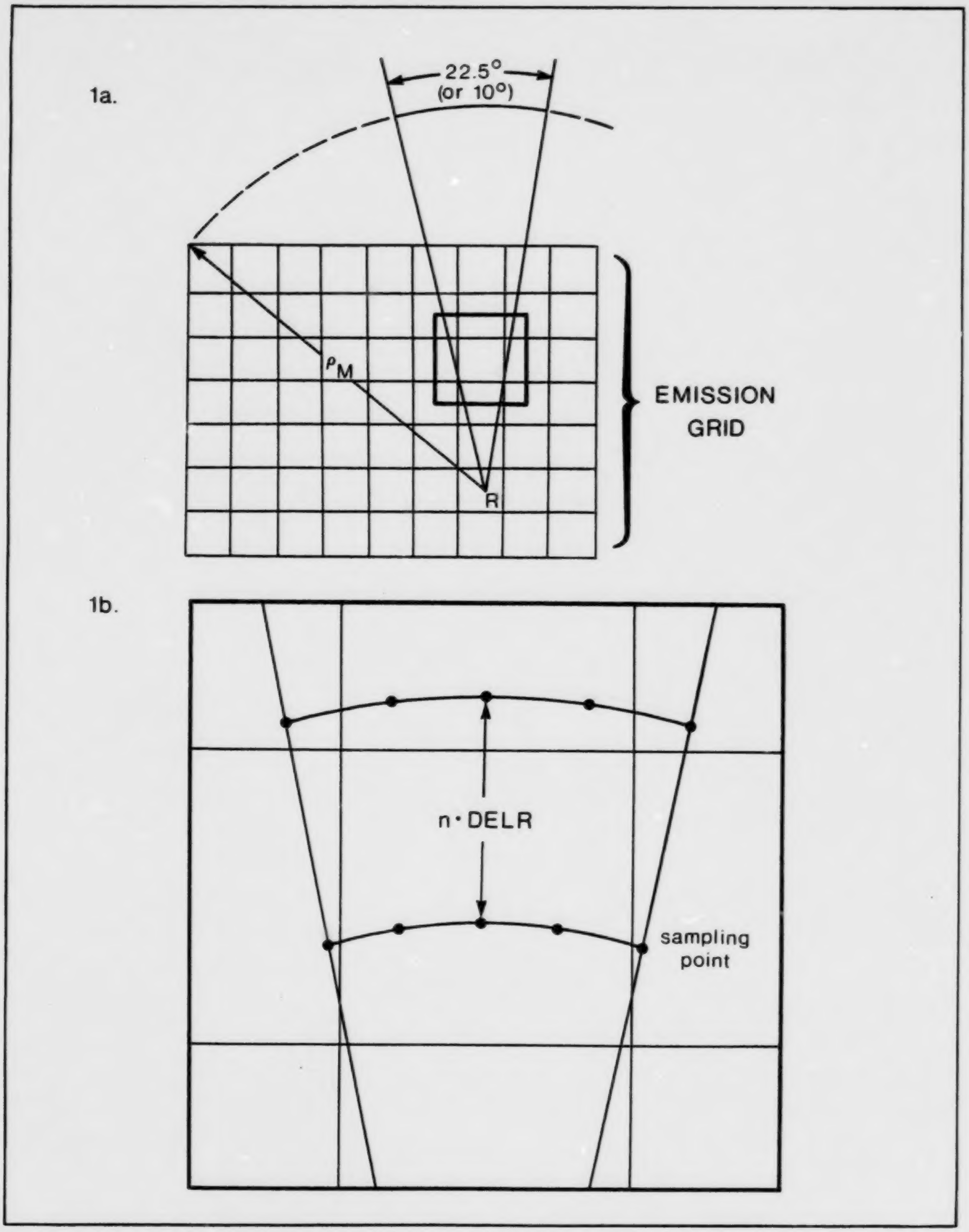

1a.
22.5°
(or 10°)
ρ_M
R
EMISSION GRID
1b.
n·DELR
sampling point

Figure 1. Illustration of sector integration (modified from Busse and Zimmerman, 1973).

TABLE 6. INCREMENTS OF INTEGRATION

Upwind range (m)	Increment *
$0 < \rho < 2500$	DELR
$2500 < \rho < 5000$	2•DELR
$5000 < \rho \leq \rho_M$	4•DELR

* The value of DELR is controlled by the user (see Section 8).

The integration over ρ (see Eq. 2) follows next and is also accomplished using the trapezoidal rule. As shown in Figure 1, the integration over ρ extends beyond the boundary of the grid system but no additional contribution to the concentration occurs since the source density is zero.

In the case where the receptor lies outside the emission grid array, the nearest distance, ρ_m, to the grid boundary as well as the maximum distance, ρ_M, is found. The lower limit to the integral over ρ is then ρ_m and the upper limit is ρ_M. Evaluating the integral from ρ_m instead of from zero results in reduced computer time.

STACK DOWNWASH

The user has the option of applying either of two stack-tip downwash algorithms: Briggs' (1974) or Bjorklund and Bowers' (1982).

Briggs Stack Downwash

The physical height is modified following Briggs (1974, p. 4). The modified physical stack height, h', is found from

$$h' = \begin{cases} h + 2[(V_s/U) - 1.5]D_s & \text{for } V_s < 1.5U, \\ h & \text{for } V_s \geq 1.5U, \end{cases} \qquad (6)$$

where h is the physical stack height (meters), V_s is stack gas velocity (m/sec), and D_s is inside stack-top diameter (meters). If the user chooses this downwash algorithm, then h' is used throughout the remainder of the plume height computation.

Bjorklund and Bowers Stack Downwash

The effects of stack-tip downwash can also be simulated by applying a correction factor to the estimated plume rise. According to Bjorklund and Bowers (1982) the stack-tip downwash correction factor, f, is defined by

$$f = \begin{cases} 1 & \text{for } U \leq V_s/1.5 \\ (3V_s - 3U)/V_s & \text{for } V_s/1.5 < U < V_s \\ 0 & \text{for } U \geq V_s \end{cases} . \qquad (7)$$

This correction factor accounts for the effects of downwash in the lee of stacks during periods when the wind speed at the stack height is greater than or equal to 0.67 times the stack gas exit velocity. It is not used (i.e., f = 1) for stacks with Froude numbers less than 3.0. The Froude number, Fr, is the ratio of the inertial force to the force of gravity for a given fluid flow. Briggs (1969) defines the Froude number for stack gas releases as

$$Fr = V_s^2/\{g[(T_s - T_a)/T_a]D_s\}. \qquad (8)$$

PLUME RISE

The user has a choice between two methods of estimating plume rise: Briggs' algorithm (1969, 1971, and 1975) and Holland's equation (1953).

Briggs Plume Rise

Neutral-Unstable Momentum Rise--

Regardless of the atmospheric stability, neutral-unstable momentum rise is calculated. The plume rise is calculated from Briggs' (1969, p. 59) Eq. 5.2:

$$\Delta H = 3D_s V_s/U. \qquad (9)$$

Briggs (1969) suggests that this equation is most applicable when

V_s/U is greater than 4. Since momentum rise occurs quite close to the point of release, the distance to final rise is set equal to zero.

Neutral-Unstable Buoyancy Rise--

The value of the Briggs buoyancy flux parameter, F (m^4/s^3), is needed for computing the distance to final rise and the plume rise. The following equation is equivalent to Briggs' (1975, p. 63) Eq. 12:

$$F = (gV_s D_s^2 \Delta T)/(4T_s), \tag{10}$$

where $\Delta T = T_s - T_a$, T_s is stack gas temperature (K), and T_a is ambient air temperature (K).

For situations where $T_s \geq T_a$, buoyancy is assumed to dominate. The distance to final rise x_f (in kilometers) is determined from the equivalent of Briggs' (1971, p. 1031) Eq. 7, and the distance to final rise is assumed to be 3.5x*, where x* is the distance at which atmospheric turbulence begins to dominate entrainment. For F less than 55,

$$x_f = 0.049F^{5/8}. \tag{11}$$

For F equal to or greater than 55,

$$x_f = 0.119F^{2/5}. \tag{12}$$

The plume rise, ΔH (in meters), is determined from the equivalent of the combination of Briggs' (1971, p. 1031) Eqs. 6 and 7. For F less than 55,

$$\Delta H = 21.425F^{3/4}/U. \tag{13}$$

For F equal to or greater than 55,

$$\Delta H = 38.71F^{3/5}/U. \tag{14}$$

If the neutral-unstable momentum rise (previously calculated from Eq. 9) is higher than the neutral-unstable buoyancy rise calculated here, momentum rise applies and the distance to final rise is set equal to zero.

Stability Parameter--

For stable situations, the stability parameter s is calculated from the equation (Briggs, 1971, p. 1031):

$$s = g(\partial\theta/\partial z)/T_a. \tag{15}$$

As an approximation, for stability class E (or 6), $\partial\theta/\partial z$ is taken as 0.02 K/m, and for stability class F (or 7), $\partial\theta/\partial z$ is taken as 0.035 K/m.

Stable Momentum Rise--

When the stack gas temperature is less than the ambient air temperature, it is assumed that the plume rise is dominated by momentum. The plume rise is calculated from Briggs' (1969, p. 59) Eq. 4.28:

$$\Delta H = 1.5[(V_s^2 D_s^2 T_a)/(4T_s U)]^{1/3} s^{-1/6}. \tag{16}$$

This is compared with the value for neutral-unstable momentum rise (Eq. 9) and the lower of the two values is used as the resulting plume height.

Stable Buoyancy Rise--

For situations where $T_s \geq T_a$, buoyancy is assumed to dominate. The distance to final rise (in kilometers) is determined by the equivalent of a combination of Briggs' (1975, p. 96) Eqs. 48 and 59:

$$x_f = 0.0020715Us^{-1/2}. \tag{17}$$

The plume rise is determined by the equivalent of Briggs' (1975, p. 96) Eq. 59:

$$\Delta H = 2.6[F/(U \cdot s)]^{1/3}. \tag{18}$$

The stable buoyancy rise for calm conditions (Briggs, 1975, pp. 81-82) is also evaluated:

$$\Delta H = 4F^{1/4} s^{-3/8}. \tag{19}$$

The lower of the two values obtained from Eqs. 18 and 19 is taken as the plume rise.

If the stable momentum rise is higher than the stable buoyancy rise calculated here, momentum rise applies and the distance to final rise is set equal to zero.

Gradual Plume Rise--

If the user exercises the gradual plume rise option and the distance upwind from receptor to source x (in kilometers) is less than the distance to final rise, the equivalent of Briggs' (1971, p. 1030) Eq. 2 is used to determine plume rise:

$$H = (160F^{1/3}h^{2/3})/U. \tag{20}$$

This height is used only for buoyancy-dominated conditions; should it exceed the final rise for the appropriate condition, the final rise is substituted instead.

Holland's Equation

Alternatively, plume rise can be estimated by Holland's equation (1953). The user supplies the product of the average wind speed and the height of plume rise ($U \cdot \Delta H$) via input variable SA (see Section 8). Holland's equation for $U \cdot \Delta H$ is as follows:

$$U \cdot \Delta H = D_s V_s \{1.5 + 0.00268p_a [(T_s - T_a)/T_s]D_s\}, \tag{21}$$

where p_a is the atmospheric pressure in millibars (the other variables are defined above). This equation frequently underestimates plume rise (Turner, 1970 and Johnson et al., 1976). Holland (1953) suggested that a value between 1.1 and 1.2 times the computed plume rise from Eq. 9 should be used for unstable conditions and a value between 0.8 and 0.9 times the computed plume rise should be used for stable conditions. This is accommodated in CDM-2.0 by adjusting the plume rise as,

$$\Delta H(\text{final}) = (SA/U)(1.4 - 0.1 \cdot ICP), \tag{22}$$

where SA is defined above and ICP is an array of values input by the user to define the dispersion curve to be associated with each stability category.

DISPERSION ALGORITHMS

As noted previously, the concentration formulas are independent of σ_y but dependent on σ_z, the vertical dispersion parameter. This results from the assumption in CDM-2.0 (and all other climatological dispersion models) that there are no variations of the wind direction frequency function within a wind-direction sector.

The user has the option of choosing among seven vertical dispersion parameter schemes; these are:

- Briggs-rural (Gifford, 1976),
- Briggs-urban (Gifford, 1976),
- Brookhaven National Laboratory (Singer and Smith, 1966),
- Klug (Vogt, 1977),
- St. Louis (Vogt, 1977),
- PGCDM (Busse and Zimmerman, 1973), and
- PGSIG (Pasquill, 1961 and Gifford, 1960).

The σ_z curves for each of the above dispersion algorithms are shown in Figure 2. The Pasquill stability categories have been used here for convenience. The BNL and St. Louis dispersion algorithms defined four curves and thus assumed different turbulence typing methods (Singer and Smith, 1966; Vogt, 1977). The PGCDM dispersion algorithm was included among the options since it is the scheme used by CDM, CDM-2.0's predecessor. The dispersion curves D1 and D2 in the PGSIG scheme represent adiabatic and subadiabatic neutral conditions, respectively. Lacking suitable temperature profile data for the lower 100 meters of the atmosphere, day and night may be substituted as criteria for adiabatic and subadiabatic lapse rates, respectively. Nighttime is typically defined as one hour prior to sunset to one hour after sunrise.

The dispersion curves shown in Figure 2 can be approximated by one of the following equations:

DISPERSION SCHEMES CONSIDERED BY CDM-2.0

- Briggs -- rural (Gifford, 1976)
- Briggs -- urban (Gifford, 1976)
- Brookhaven National Laboratory, BNL (Singer and Smith, 1966)
- Klug (Vogt, 1977)
- St. Louis (Vogt, 1977)
- PGCDM (Busse and Zimmerman, 1973)
- PGSIG (Pasquill, 1961 and Gifford, 1960)

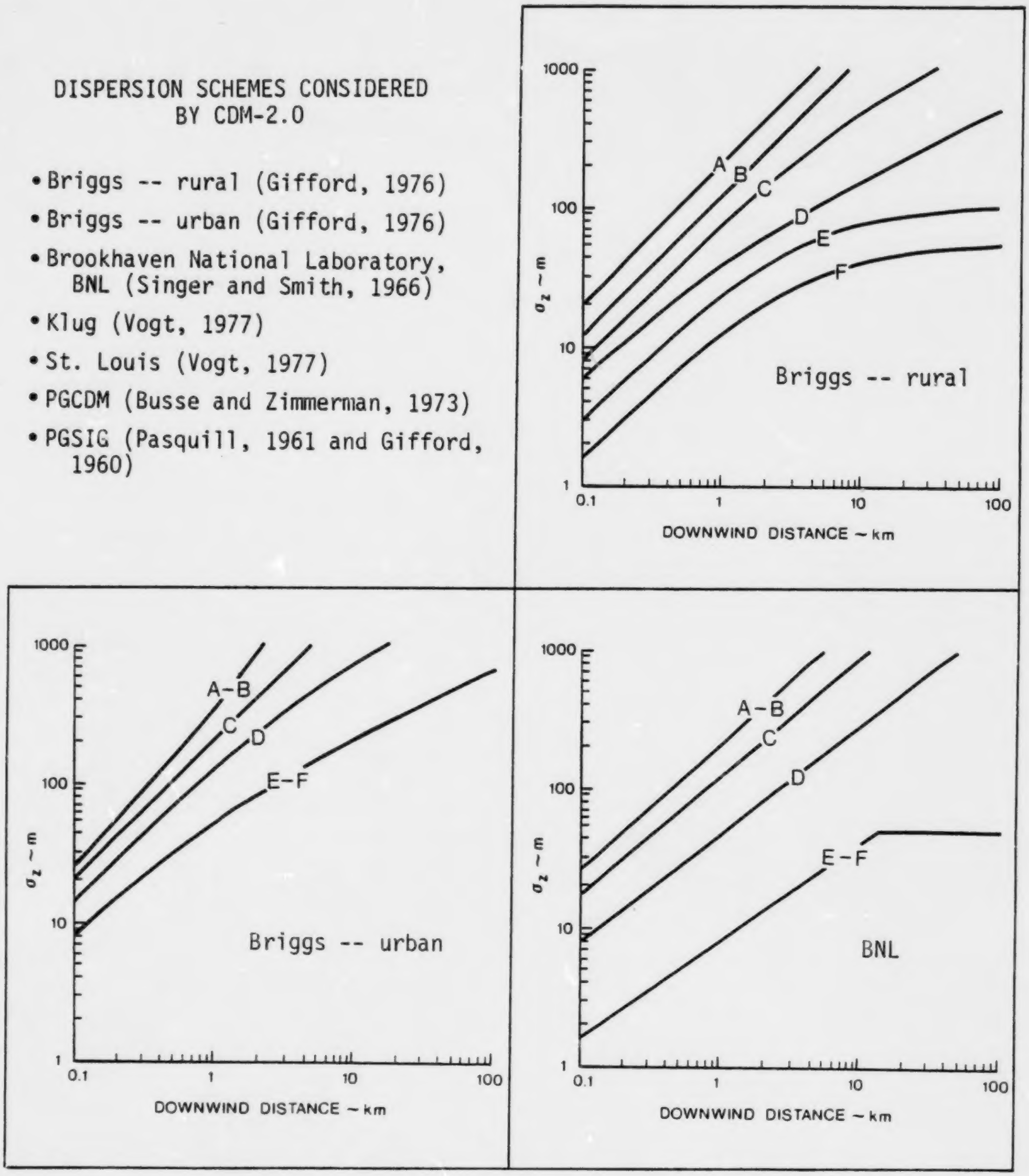


Figure 2. σ_z curves by stability class for the seven vertical dispersion schemes considered by CDM-2.0.

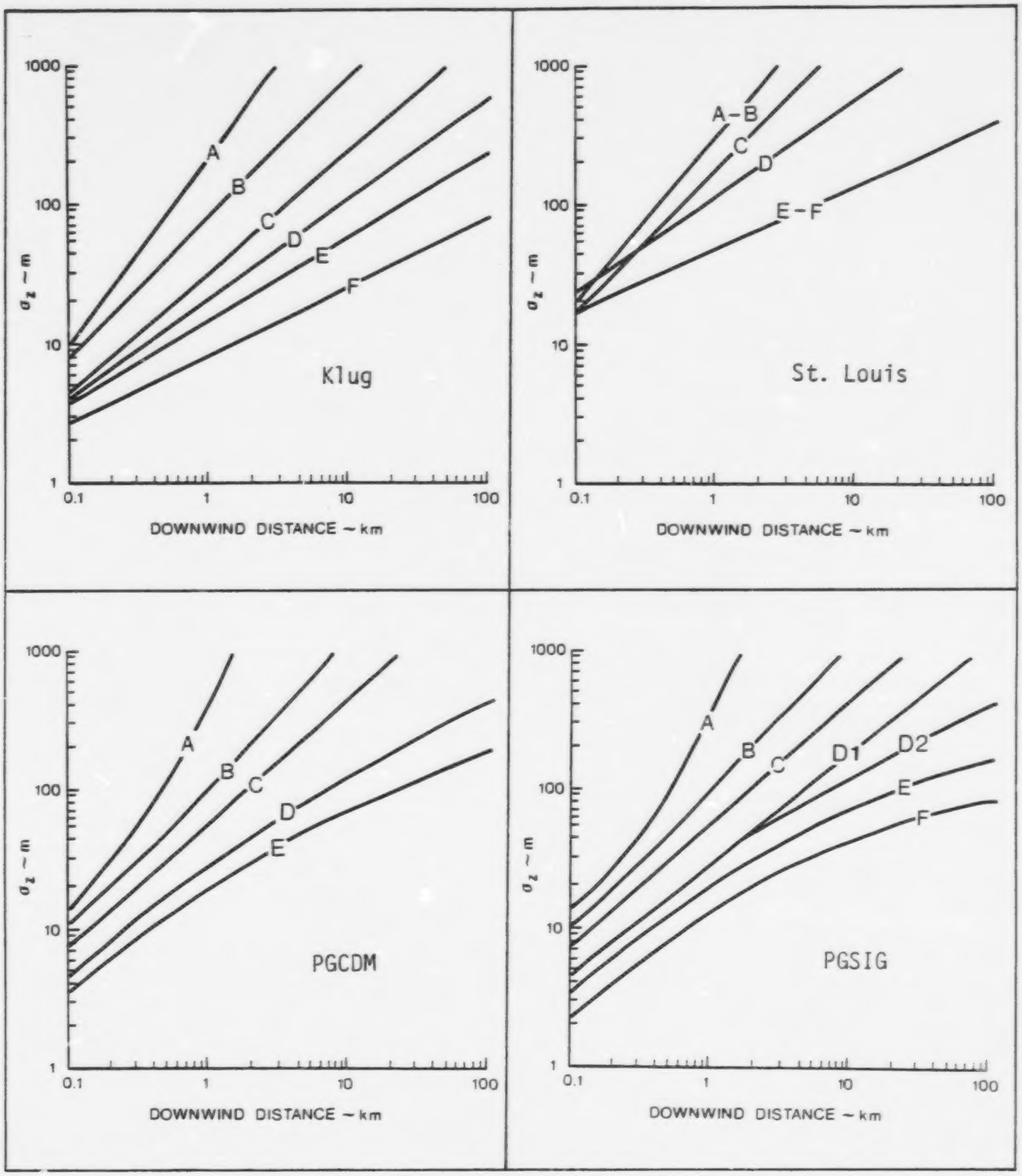


Figure 2. (continued)

$$\sigma_z = a\rho/(1 + b\rho)^c \quad \text{and} \tag{23}$$

$$\sigma_z = a\rho^b, \tag{24}$$

where a, b, and c are constants and ρ is the downwind distance. Eq. 23 is used to simulate the Briggs-rural and -urban schemes; the power-law formula shown in Eq. 24 represents the BNL, Klug, St. Louis, PGCDM, and PGSIG algorithms. Parameters a, b, and c are provided in Tables 7, 8, and 9.

CALIBRATION OF COMPUTED CONCENTRATION

If the calibration constants of the linear expression

$$C' = A + BC, \tag{25}$$

where

C' = calibrated concentration,
A, B = calibration constants, and
C = computed concentration,

are known, they may be entered into the program and used to obtain a calibrated concentration. The calibration constants are determined from regression analysis of observed air quality and the computed concentrations produced by the model. Thus, at least one initial run of the model must be made without the calibration feature. Once the model has been run to obtain computed concentrations, a regression procedure may be followed using computed versus observed concentrations. After finding the desired constants, calibrated concentrations can be obtained on subsequent operations of the model.

GRID SYSTEM AND AREA EMISSIONS

A rectangular grid array of uniform-sized squares is used to overlay the region of interest. The main purpose of this grid is to catalogue the emission inventory by area sources. There is some flexibility in the size of the grid squares in that the

TABLE 7. CONSTANTS FOR VERTICAL DISPERSION EQUATIONS USED BY FIVE DISPERSION SCHEMES

Dispersion algorithm	Eq	Const	Pasquill Stability Class						
			A	B	C	D,day	D,night	E	F
Briggs-rural	23	a	0.2000	0.1200	0.0800	0.0600	0.0600	0.0300	0.0160
		b	0.0000	0.0000	0.0002	0.0015	0.0015	0.0003	0.0003
		c	1.0000	1.0000	0.5000	0.5000	0.5000	1.0000	1.0000
Briggs-urban	23	a	0.2400	0.2400	0.2000	0.1400	0.1400	0.0800	0.0800
		b	0.0010	0.0010	0.0000	0.0003	0.0003	0.0015	0.0015
		c	-0.5000	-0.5000	1.0000	0.5000	0.5000	0.5000	0.5000
BNL	24	a	0.4000	0.4000	0.3300	0.2200	0.2200	0.0600	0.0600
		b	0.9100	0.9100	0.8600	0.7800	0.7800	0.7100	0.7100
Klug	24	a	0.0170	0.0720	0.0760	0.1400	0.1400	0.2170	0.2620
		b	1.3800	1.0210	0.8790	0.7270	0.7270	0.6100	0.5000
St. Louis	24	a	0.0790	0.0790	0.1310	0.9100	0.9100	1.9300	1.9300
		b	1.2000	1.2000	1.0460	0.7020	0.7020	0.4650	0.4650

TABLE 8. CONSTANTS FOR THE VERTICAL DISPERSION PARAMETER EQUATION USED IN THE PGCDM SCHEME *

Stability class	Distance (m)					
	100 to 500		500 to 5000		5000 to 50000	
	a	b	a	b	a	b
A	0.0383	1.2812	0.0002539	2.0886	0.2539E-3	2.0886
B	0.1393	0.9467	0.04936	1.1137	0.4936E-1	1.1137
C	0.1120	0.9100	0.1014	0.9260	0.1154	0.9109
D, day	0.0856	0.8650	0.2591	0.6869	0.7368	0.5642
D, night	0.0856	0.8650	0.2591	0.6869	0.7368	0.5642
E	0.0818	0.8155	0.2527	0.6341	1.2969	0.4421
F	0.0545	0.8124	0.2017	0.6020	1.5763	0.3606

* Constants are to be used in conjunction with Eq. 24.

TABLE 9. CONSTANTS FOR THE VERTICAL DISPERSION PARAMETER EQUATION USED IN THE PGSIG SCHEME *

Stability class	Distance (km)	Constants	
		a	b
A	< 0.1	122.80	0.9447
	0.1 - 0.15	158.08	1.0542
	0.15 - 0.2	170.22	1.0932
	0.2 - 0.25	179.52	1.1262
	0.25 - 0.3	217.41	1.2644
	0.3 - 0.4	258.89	1.4094
	0.4 - 0.5	346.75	1.7283
	> 0.5	453.85	2.1166
B	< 0.2	90.673	0.93198
	0.2 - 0.4	98.483	0.98332
	> 0.4	109.300	1.09710
C		61.141	0.91465
D, day		33.504	0.8098
D, night	< 0.3	34.459	0.86974
	0.3 - 1	32.093	0.81066
	1 - 3	32.093	0.64403
	3 - 10	33.504	0.60486
	10 - 30	36.650	0.56589
	> 30	44.053	0.51179
E	< 0.1	24.260	0.83660
	0.1 - 0.3	23.331	0.81956
	0.3 - 1	21.628	0.75660
	1 - 2	21.628	0.63077
	2 - 4	22.534	0.57154
	4 - 10	24.703	0.50527
	10 - 20	26.970	0.46713
	20 - 40	35.420	0.37615
	> 40	47.618	0.29592
F	< 0.2	15.209	0.81558
	0.2 - 0.7	14.457	0.78407
	0.7 - 1	13.953	0.68465
	1 - 2	13.953	0.63227
	2 - 3	14.823	0.54503
	3 - 7	16.187	0.46490
	7 - 15	17.836	0.41507
	15 - 30	22.651	0.32681
	30 - 60	27.074	0.27436
	> 60	34.219	0.21716

* Constants are to be used in conjunction with Eq. 24.

computer program accepts information on emissions from squares whose sides have lengths which are integer multiples of the length of the side of the basic square. Thus, if the basic square has a length s, emission information for a larger square whose side has a length, say 4s, is accepted by the model and distributed uniformly into 16 basic squares.

The origin of the overlay grid is located in the lower left-hand corner of the array with the X-axis pointing toward the east and the Y-axis pointing toward the north. With respect to the map coordinates of the region, the origin of the grid array is to be located at some suitably chosen point in the lower left-hand section of the region under consideration. The length of the side of a square is expressed in meters. However, the map coordinates can be expressed in any suitable units, say, thousands of feet or kilometers. The magnitude of the length of a square depends on how many squares are needed in the emission inventory of a region. For example, CDM-2.0 is dimensioned at present to handle 2500 area sources (and 200 point sources); thus, the grid square dimension must be chosen such that the limiting criteria of 2500 area sources is not exceeded. Computation can be performed for any number of receptor points.

OTHER CONSIDERATIONS

Initial Dispersion

The value of initial σ_z for point sources due to building effects is modeled as a function of the height above ground of the stack, h. Table 10 summarizes the relationship between initial σ_z and stack height.

TABLE 10. RELATIONSHIP BETWEEN INITIAL σ_z AND STACK HEIGHT

Stack height, h (m)	Initial σ_z (m)
$0 < h \leq 20$	30
$20 < h \leq 50$	$50 - h$
$50 < h$	0

Buoyancy-Induced Dispersion

For strongly buoyant plumes, entrainment as the plume ascends through the ambient air contributes to vertical spread. Pasquill (1976) suggests that this induced dispersion, σ_{zb}, can be approximated by the plume rise divided by 3.5. The effective dispersion can then be determined by adding variances:

$$\sigma_{ze} = (\sigma_{zb}^2 + \sigma_z^2)^{1/2} , \tag{26}$$

where σ_{ze} is the effective dispersion, and σ_z is the dispersion due to ambient turbulence levels.

Effluent Rise for Area Sources

CDM-2.0 can consider changes in effective height with wind speed for area sources. The input area source height, H_a, is assumed to be the average physical height of the area source plus the effluent rise with a wind speed of 5 m/sec. The user specifies the fraction, f_e, of the input height that represents the physical height, h. This fraction is the same for all area sources in the inventory. The relationship among H_a, f_e, and h is as follows:

$$h = f_e H_a . \tag{27}$$

If $f_e = 1$, there is no rise and the input height is the effective height for all wind speeds. For any wind speed, U, the rise is assumed to be inversely proportional to U and is determined by

$$\Delta H = (5/U)(H_a - h); \tag{28}$$

the effective height is then

$$H = h + \Delta H. \tag{29}$$

SECTION 6

EXAMPLE PROBLEM

In this section, a hypothetical problem is provided to illustrate the use of CDM-2.0 and the type of information it provides. Details concerning input and output for this example are discussed in Section 10.

Figure 3 shows the city limits of Test City along with the locations of sampling sites and major point sources of pollution. Minor point sources and area sources were cataloged and gridded. The emission grid is shown in Figure 3. The area and point source inventory is summarized in Table 11; all necessary source information is contained there.

TABLE 11. POLLUTION SOURCE INVENTORY FOR TEST CITY.

Location			Emission rate			Stack parameters		
X (km)	Y (km)	Width (km)	SO_2 (g/s)	Part (g/s)	Source height (m)	Dia (m)	Speed (m/s)	Temp (°C)
568.5	4403.4	--	1365.00	527.63	150	0.0	0.0	0
584.2	4391.6	--	1580.36	789.60	90	8.7	15.2	149
577.0	4401.1	--	221.76	34.13	30	0.7	17.8	515
574.1	4401.5	--	110.25	54.08	23	1.4	15.2	260
562.5	4402.5	5	1.37	1.68	0	--	--	--
567.5	4402.5	5	1.26	1.79	0	--	--	--
572.5	4402.5	5	5.25	3.99	10	--	--	--
577.5	4402.5	5	1.47	13.13	0	--	--	--
582.5	4402.5	5	1.20	1.58	0	--	--	--
562.5	4397.5	5	2.62	1.47	10	--	--	--
567.5	4392.5	10	32.66	21.11	15	--	--	--
577.5	4397.5	5	5.46	3.99	10	--	--	--

(continued)

TABLE 11. (continued)

Location			Emission rate			Stack parameters		
X (km)	Y (km)	Width (km)	SO_2 (g/s)	Part (g/s)	Source height (m)	Dia (m)	Speed (m/s)	Temp (°C)
582.5	4397.5	5	6.62	5.78	10	--	--	--
562.5	4392.5	5	2.63	1.16	10	--	--	--
577.5	4392.5	5	7.88	5.15	20	--	--	--
582.5	4392.5	5	5.25	3.68	10	--	--	--
562.5	4387.5	5	2.73	1.37	0	--	--	--
567.5	4387.5	5	2.42	1.89	10	--	--	--
572.5	4387.5	5	5.36	4.10	10	--	--	--
577.5	4387.5	5	5.57	3.89	10	--	--	--
582.5	4387.5	5	2.84	1.47	10	--	--	--

The meteorology for Test City and its environs is summarized in Figures 4 and 5. The wind rose indicates that north winds predominate, occurring almost 14% of the time. However, there is a secondary peak from the east-southeast. The stability distribution for Test City (Figure 5) shows the predominance of neutral conditions throughout the year.

Computed concentrations at the sampling sites shown in Figure 3 are listed in Table 12. Note that CDM-2.0 provides area and point source contributions. In this example, the point sources exhibit the greatest impact on the receptors.

Optional output from CDM-2.0 includes point and area concentration roses and histograms of concentration by stability class. Figure 6 illustrates the type of information available from CDM-2.0, except that CDM-2.0 provides the information in the form of tables. As mentioned earlier, neutral conditions dominate and this is confirmed in the concentration versus stability histograms. As noted from the concentration roses, north-northwest, north-northeast, northeast, and south-southeast winds account for over 70% of the total concentration (at this particular receptor), which corresponds to the directions of the four point sources.

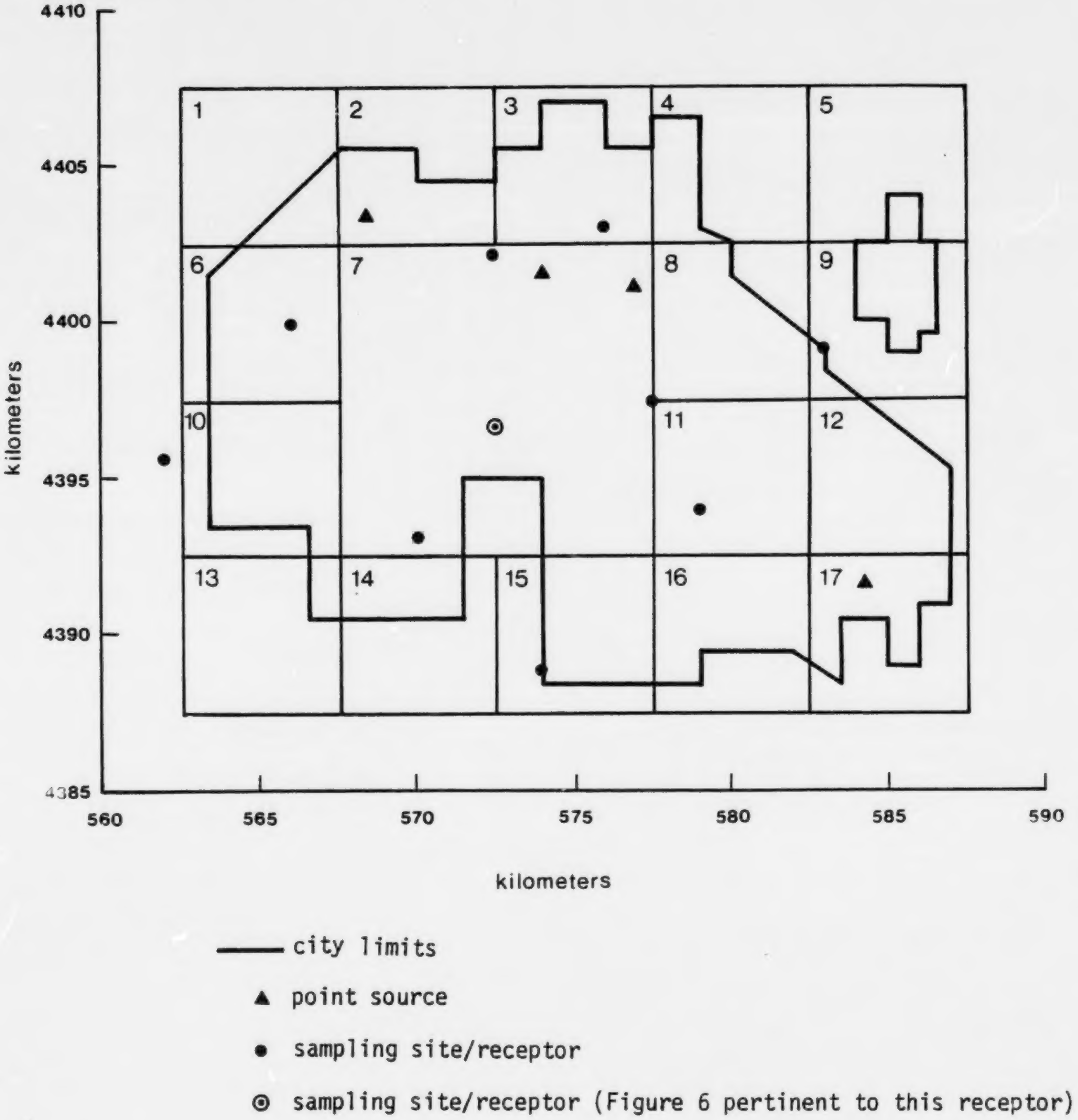

4410
4405
4400
4395
4390
4385
kilometers
560
565
570
575
580
585
590
kilometers
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
city limits
▲ point source
● sampling site/receptor
⊙ sampling site/receptor (Figure 6 pertinent to this receptor)

Figure 3. Test City base map (modified from Brubaker et al., 1977).

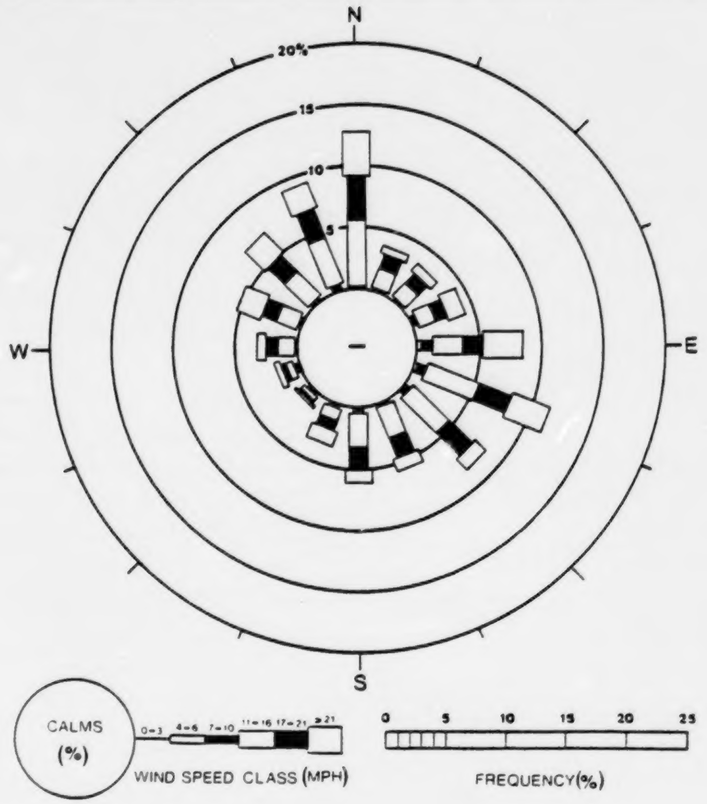


Figure 4. Wind rose for Test City.

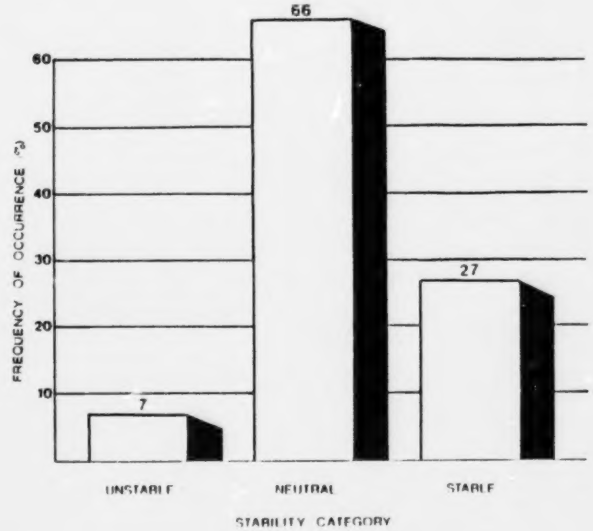


Figure 5. Stability distribution for Test City.

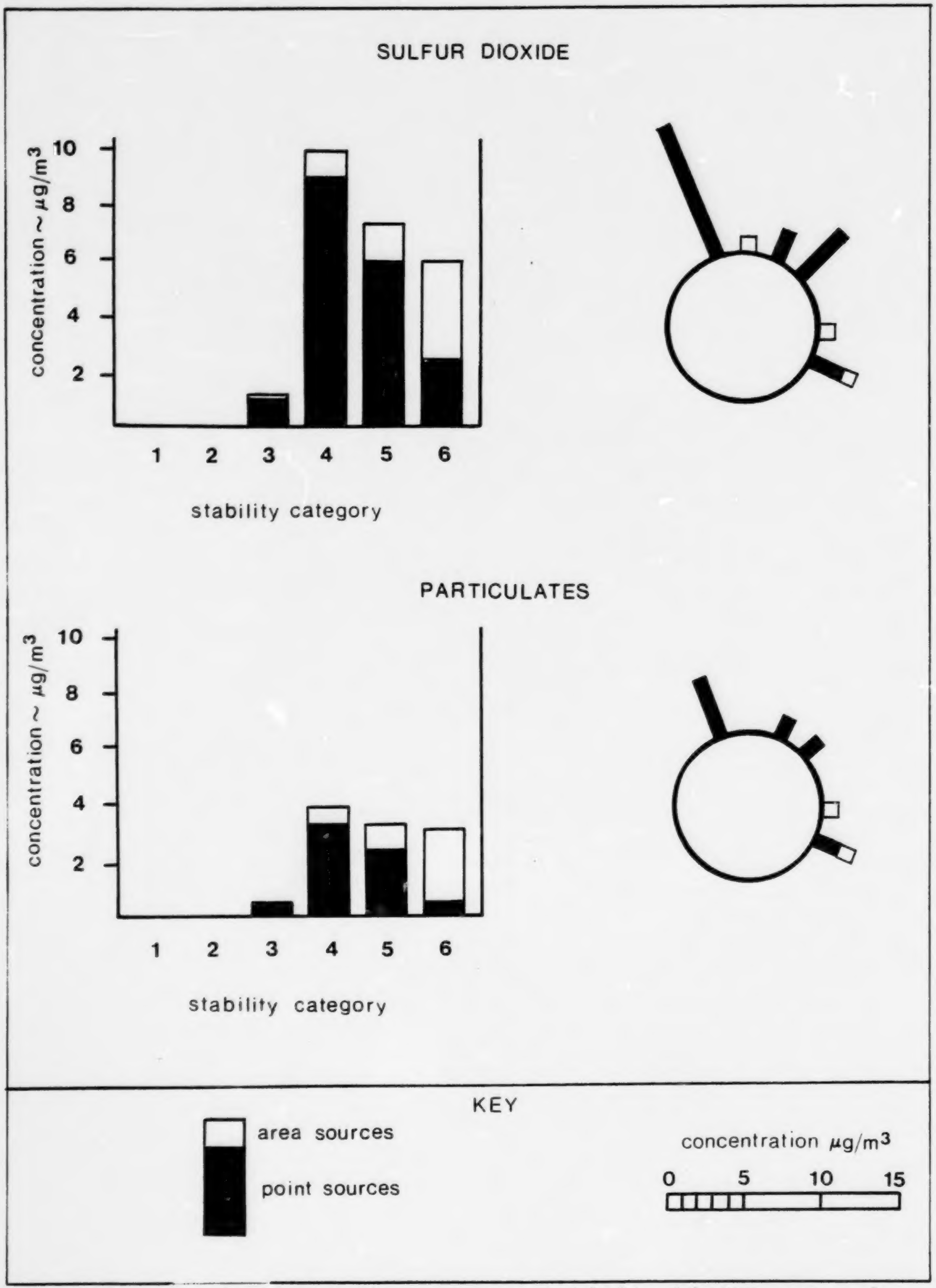


Figure 6. Concentration versus stability histograms and concentration roses for the receptor of Figure 3.

Both input stream and abridged output listing for this problem are provided in Section 10.

TABLE 12. COMPUTED CONCENTRATIONS AT SELECTED SITES IN TEST CITY.

Location		Concentrations ($\mu g/m^3$)					
		Area sources		Point sources		Total	
X (km)	Y (km)	SO_2	Part	SO_2	Part	SO_2	Part
570.0	4393.2	5.4	3.8	14.8	5.5	20.3	9.3
573.9	4388.9	4.6	3.4	9.5	3.6	14.1	7.0
572.4	4402.2	4.9	4.3	39.5	13.0	44.4	17.3
579.0	4394.0	5.4	4.3	15.3	4.4	20.7	8.7
583.0	4399.2	4.5	4.9	11.3	3.0	15.8	7.9
562.0	4395.7	2.7	1.9	6.2	2.2	8.9	4.0
566.1	4400.0	4.2	3.1	12.5	4.1	16.7	7.3
572.5	4396.7	6.0	4.3	17.5	6.3	23.5	10.6
577.5	4397.5	5.5	4.4	34.2	7.6	39.8	12.0
576.0	4403.0	4.4	4.8	27.8	6.2	32.3	11.0

SECTION 7

COMPUTER ASPECTS OF THE MODEL

This section discusses CDM-2.0 from a software design and programming perspective, and is intended to give the reader a general knowledge of the computational system, rather than a detailed description of each subroutine. The overall structure of the program, a brief description of each subroutine, and the general processing flow are given here. Also provided is the overall system flow, the input/output media, data flow, and alternative processing.

SYSTEM FLOW

An overview of the system will be beneficial to the reader. Figure 7 illustrates the input and output media as well as data flow for CDM-2.0. Input data requirements are contained in either one or two files depending on the user assignment of variable IRD (see Section 8). Output is in two forms: printed output and card image output, usually going to a disk file. Card-image records containing the calculated concentrations at each receptor are written for use in computer programs that analyze information produced by CDM-2.0. As discussed in Section 5, a regression program must be applied to obtain calibration constants. Additionally, the disk file output can be used with user-supplied plot routines to obtain isopleth plots of concentration.

In addition to the records containing the concentrations from area and point sources, further output may be produced if the NROSE option is used (see Section 8). If NROSE is specified as greater than zero, additional records are written. Concentration versus stability histograms and concentration roses for both pollutants and both source types are provided.

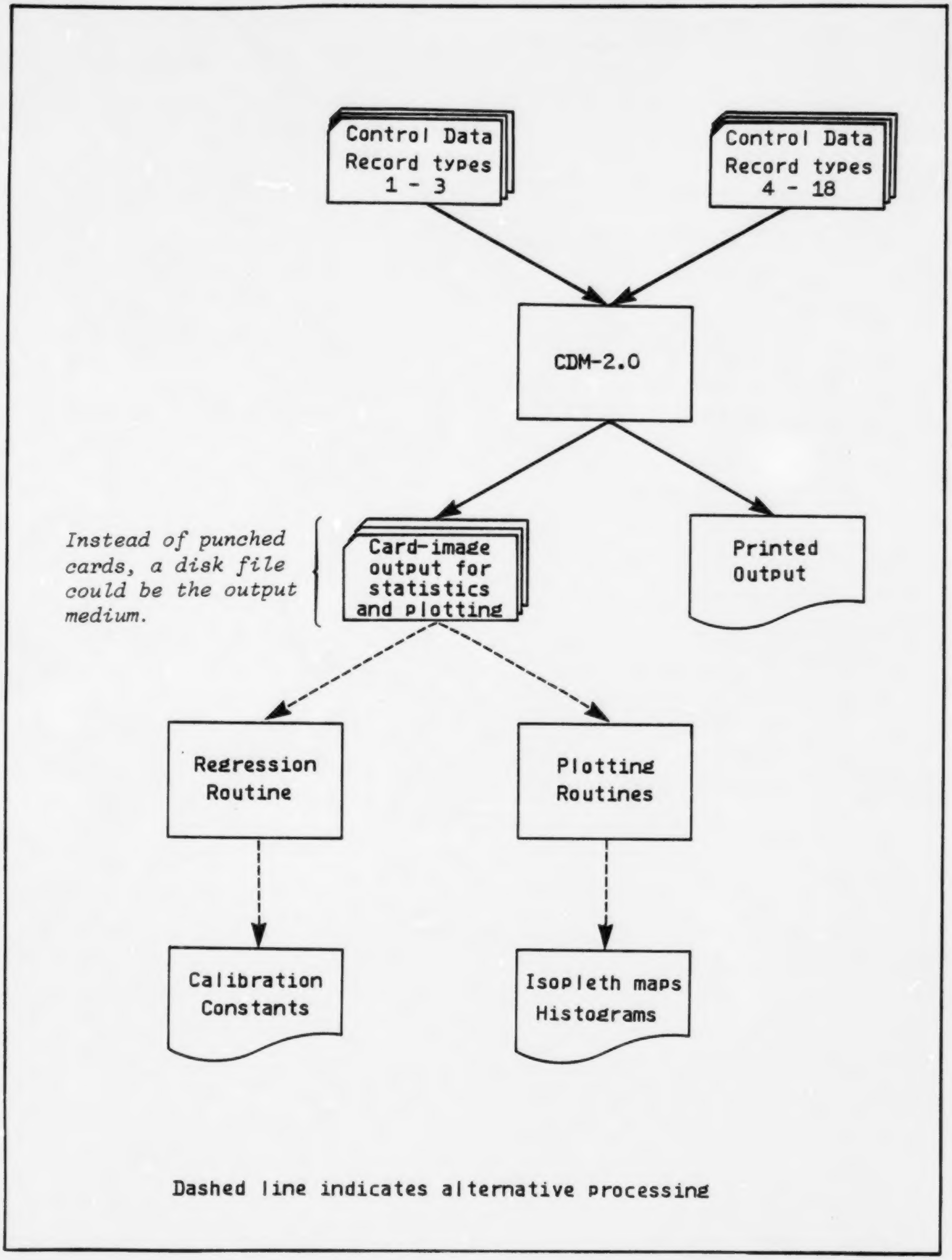

Control Data Record types 1 - 3
Control Data Record types 4 - 18
CDM-2.0
Instead of punched cards, a disk file could be the output medium.
Card-image output for statistics and plotting
Printed Output
Regression Routine
Plotting Routines
Calibration Constants
Isopleth maps Histograms
Dashed line indicates alternative processing

Figure 7. System flow for CDM-2.0.

The input/output (I/O) units used by CDM-2.0 are summarized in Table 13.

TABLE 13. INPUT/OUTPUT UNITS USED BY CDM-2.0

FORTRAN unit	I/O unit	Mode	Contents
5	Disk	input	Program control and input data (record types 1-3)
IRD*	Disk	input	Program control and input data (record types 4-18)
IWR*	Printer or disk	output	Output listing
IPU*	Disk or magnetic tape	output	Concentration data

* See Section 8.

STRUCTURE OF CDM-2.0

CDM-2.0 consists of a main routine and nine subroutines as shown in Figure 8. Program control data, meteorological data, and source information are read by subroutine CLINT. The main routine reads receptor data until an end-of-file is encountered and then execution is terminated. With the exception of one warning message generated by CALQ, all output is performed by the main routine or by subroutine CLINT. Brief descriptions of the main program and subroutines follow.

CDM-2.0 -- The main program first calls subroutine CLINT to read all the input data except the receptor information which is subsequently read by the main program. It directs the concentration calculations by calling subroutines CALQ, AREA, and POINT. It is also responsible for printing and writing concentration results to a file.

CLINT -- This subroutine is called by the main routine to read program control data, meteorological data, and source information. It also echoes input according to user specification. It calls subroutine VIRTX.

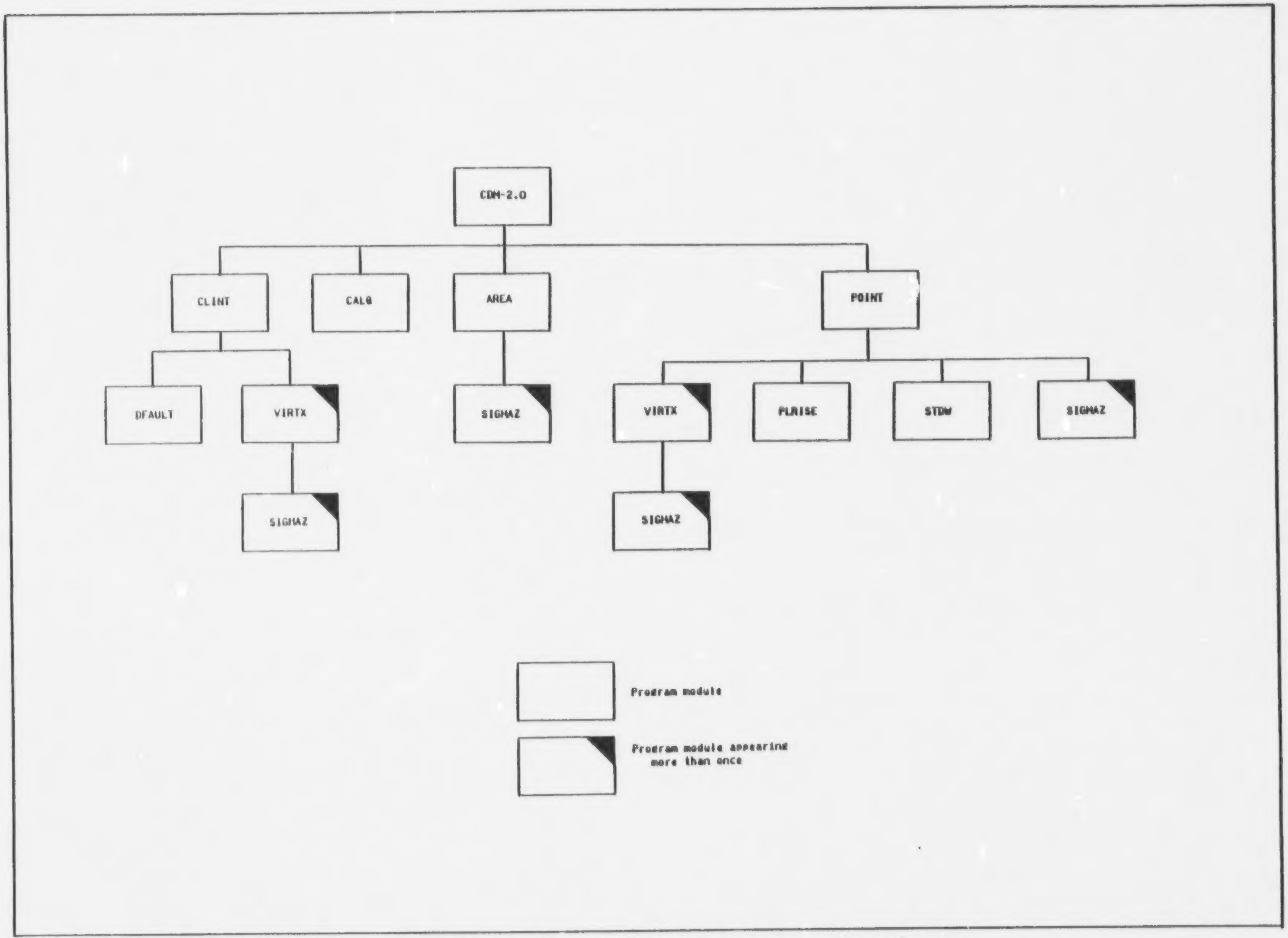

CDM-2.0
CLINT
CALG
AREA
POINT
DFAULT
VIRTX
SIGMAZ
VIRTX
PLRISE
STDW
SIGMAZ
SIGMAZ
SIGMAZ
Program module
Program module appearing more than once

Figure 8. CDM-2.0 program structure.

CALQ -- Called by the main program, subroutine CALQ computes the area source vector for each direction sector. The area source vector contains emission rates for two pollutants and release heights at various upwind distances.

AREA -- This subroutine is called by the main routine to calculate concentrations due to area sources. It calls subroutine SIGMAZ.

POINT -- Subroutine POINT is called by the main routine to calculate concentrations due to point sources. It calls subroutines VIRTX, STDW, and SIGMAZ.

DFAULT -- This second level subroutine sets some of the user-defined options; see Appendix A for further discussion. It is called by subroutine CLINT if the user turns on the default option.

PLRISE -- Called by subroutine POINT, this module calculates plume rise according to the methods of Briggs (1969, 1971, and 1975).

VIRTX -- This second level subroutine is called by CLINT and POINT; it computes the virtual distance applicable to the user-specified initial dispersion. VIRTX calls SIGMAZ to estimate vertical dispersion.

STDW -- This subroutine is called by POINT to estimate stack downwash.

SIGMAZ -- This subroutine is called by AREA, POINT, and VIRTX to calculate the vertical dispersion parameter. The user can choose among seven different schemes.

Figure 9 is an abbreviated flow diagram of CDM-2.0 showing its major loops and relationships among the subroutines and the main routine. A set of program flow charts is provided in Appendix B.

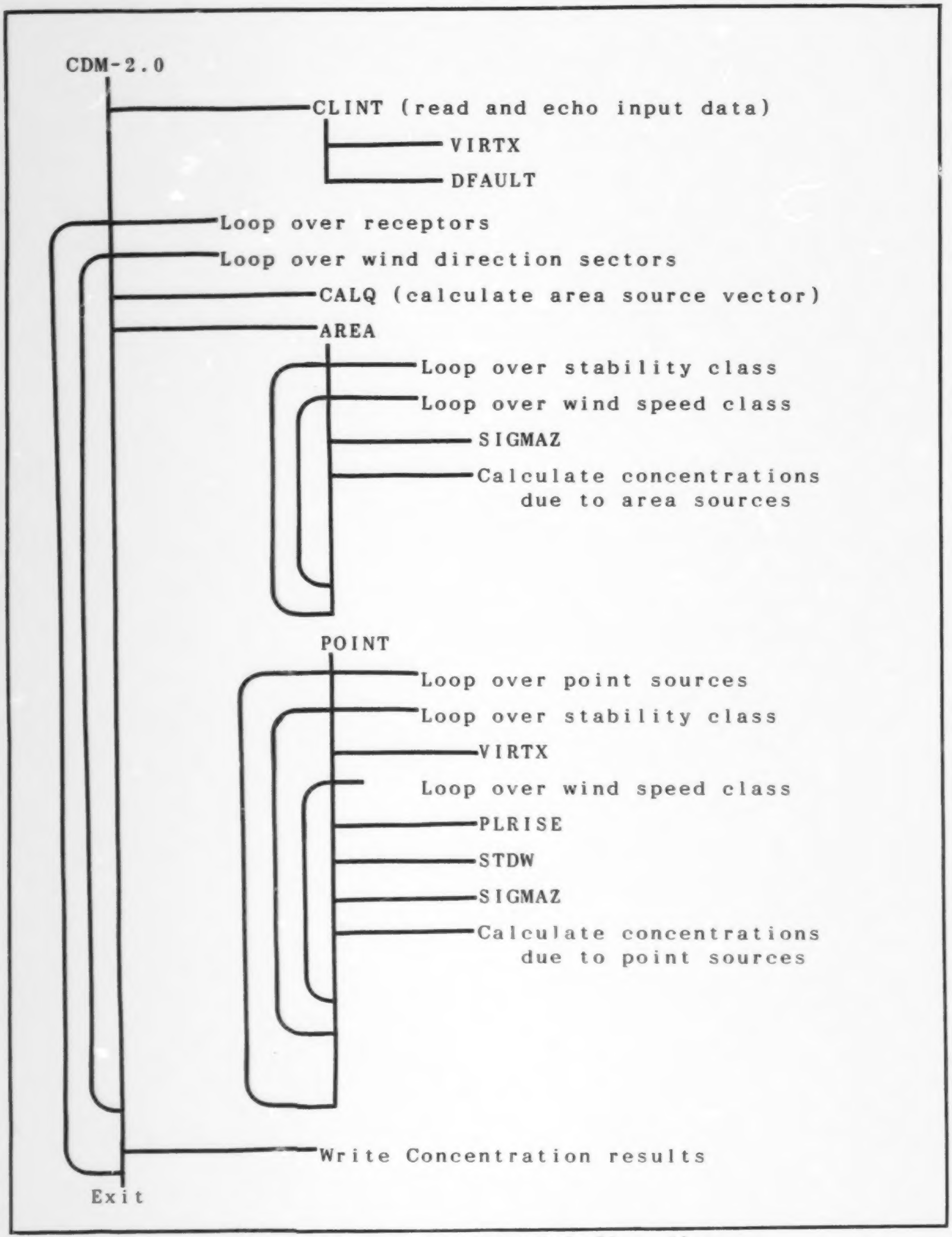

CDM-2.0
CLINT (read and echo input data)
VIRTX
DFAULT
Loop over receptors
Loop over wind direction sectors
CALQ (calculate area source vector)
AREA
Loop over stability class
Loop over wind speed class
SIGMAZ
Calculate concentrations due to area sources
POINT
Loop over point sources
Loop over stability class
VIRTX
Loop over wind speed class
PLRISE
STDW
SIGMAZ
Calculate concentrations due to point sources
Write Concentration results
Exit

Figure 9. CDM-2.0 flow diagram.

NON-STANDARD FEATURES

The PARAMETER statement, which is used in the main program, is not an ANSI FORTRAN statement, and hence may not be available in the user's FORTRAN compiler. As PARAMETER allows constants to be referenced by symbolic names, it facilitates the updating of programs in which the only changes between compilations are in the values of certain constants. In CDM-2.0, the PARAMETER statement initializes the following variables:

NPTS - number of point sources,
NQLIM - number of upwind integration steps allowed,
NASE - number of east-west area-source grid squares,
NASN - number of north-south area-source grid squares,

which in turn are used to dimension several arrays. If the user's compiler does not support the PARAMETER statement, the variables NPTS, NQLIM, NASE, and NASN must be hardcoded. The best way to do this is to perform global changes using a text editor.

SECTION 8

INPUT DATA PREPARATION

RECORD INPUT SEQUENCE

There are 18 record types read by CDM-2.0. Six of these are free format input, eight are fixed format, three are of user-specified format, and one is a blank record. While the free format is easy to use, care should be taken to ensure that every variable is given a value in the correct order. Also each variable should be separated by a comma and should conform to the variable name type (integer or real). Table 14 lists the record types and input associated with each record. A brief description of each input variable is given in Table 15 with the appropriate units. Under the "Format" column of Table 15, FF represents free format and US indicates user-specified format.

TABLE 14. SUMMARY OF RECORD TYPES FOR INPUT DATA.

Record type	Description	Format type	Input unit	Calling subroutine
1	HEADNG - run title	Fixed	5	CLINT
2	NSO2,PNAME	Fixed	5	CLINT
3	AROS,PROS,IRUN,NLIST,IRD, IWR,IPU,CA,CB	Fixed	5	CLINT
4	N1636,NP50,NPDH,NSTDW,NGRAD, FAC,RCEPTZ,KELVIN,NDEF	Free	IRD	CLINT
5	KLOW,ICA	Free	IRD	CLINT
6	KHIGH,ICP	Free	IRD	CLINT
7	DELR,RAT,CV,XG,YG,TOA,TXX	Fixed	IRD	CLINT
8	DINT,YD,YN,SZA,GB	Fixed	IRD	CLINT
9	UE	Free	IRD	CLINT
10	U	Free	IRD	CLINT
11	H	Free	IRD	CLINT
12	FMETEO	Fixed	IRD	CLINT
13	F	FMETEO	IRD	CLINT
14	FSOURC	Fixed	IRD	CLINT
15	X,Y,TX,S1,S2,SH,D,VS,T,SA	FSOURC	IRD	CLINT
16	Blank Sentinel Card (End of source input)	--	IRD	CLINT
17	FRECPT	Fixed	IRD	MAIN
18	RX,RY,KPX(9),KPX(10),NROSE	FRECPT	IRD	MAIN

TABLE 15. RECORD INPUT SEQUENCE FOR CDM-2.0

Record type, Variable	Column	Format	Variable description (units)
Record type 1			
HEADNG	1-80	20A4	80-character description or title of model run
Record type 2			
NSO2	1- 1	I1	Pollutant number for SO_2 = 0, SO_2 not considered = 1, pollutant 1 is SO_2 = 2, pollutant 2 is SO_2
PNAME	5-12	2A4	Names of two pollutants to be modeled (e.g., SO_2, TSP)
Record type 3			
AROS	1- 8	2A4	Alphanumeric area rose output identification
PROS	9-16	2A4	Alphanumeric point rose output identification
IRUN	17-21	I5	User-defined run identification
NLIST	22-26	I5	Control for printed output > 0, echo set-up information, meteorology, and list concentration results = 0, echo set-up information, meteorology, source, and list concentration results < 0, list concentration results only
IRD	27-31	I5	FORTRAN logical unit number - read
IWR	32-36	I5	FORTRAN logical unit number - print
IPU	37-41	I5	FORTRAN logical unit number - punch
CA	42-59	2F9.0	Intercepts of calibration for both pollutants ($\mu g/m^3$)
CB	60-77	2F9.0	Slopes of calibration for both pollutants

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 4			
N1636	---	FF	Number of wind directions used in the meteorological joint frequency function (16 or 36)
NP50	---	FF	Initial dispersion option $\leq$ 0, no action taken on point sources with release heights below 50 m > 0, initially dispersed as described in Section 5
NPDH	---	FF	Buoyancy-induced dispersion option $\leq$ 0, no action taken $\geq$ 0, include buoyancy-induced dispersion effects (Pasquill, 1976) in point source dispersion
NSTDW	---	FF	Stack downwash option < 0, Bjorklund, Bowers (1982) stack downwash used = 0, no action taken > 0, Briggs (1974) stack downwash considered
NGRAD	---	FF	Gradual plume rise option = 0, no action taken > 0, gradual plume rise used
FAC	---	FF	Effluent rise for area sources See Section 5 for description.
RCEPTZ	---	FF	Height above ground of all receptors (meters)
KELVIN	---	FF	Units flag for stack gas temperature < 0, °F = 0, °C > 0, K
NDEF	---	FF	Default option = 0, no action taken > 0, implement default option (see Appendix A)

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 5			
KLOW	---	FF	Dispersion parameter scheme for area sources
ICA	---	FF	Array of six values defining dispersion curves (as defined by KLOW) to be used for the six stability categories summarized in the joint frequency function
Record type 6			
KHIGH	---	FF	Dispersion parameter scheme for point sources
ICP	---	FF	Array of six values defining dispersion curves (as defined by KHIGH) to be used for the six stability categories summarized in the joint frequency function
Record type 7			
DELR	1- 6	F6.0	Radial increment (meters)
RAT	7-12	F6.0	Length of basic emission grid square (user units)
CV	13-18	F6.0	Conversion factor (m/user units) CV·RAT = emission grid interval in meters
XG	19-24	F6.0	East-west map coordinate of the southwest corner of the emission grid array (user units)
YG	25-30	F6.0	North-south map coordinate of the southwest corner of the emission grid array (user units)
TOA	31-36	F6.0	Mean atmospheric temperature (°C)
TXX	37-42	F6.0	Width of the basic emission grid square (meters)
Record type 8			
DINT	1- 6	F6.0	Number of intervals used to integrate over a 22.5° or 10° sector. Maximum value is 20; minimum is 2.

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
YD	7-12	F6.0	Ratio of the daytime emission rate to the average 24-hour emission rate
YN	13-18	F6.0	Ratio of the nighttime emission rate to the average 24-hour emission rate
SZA	19-54	6F6.0	Initial σ_z for area sources (meters)
GB	55-66	2F6.0	Decay half-life for the two pollutants (hours)
Record type 9			
UE	---	FF	Array of six values defining wind profile exponents to be associated with the six stability categories summarized in the joint frequency function
Record type 10			
U	---	FF	Array of six values defining wind speeds to be associated with the six wind speed categories summarized in the joint frequency function (m/sec)
Record type 11			
HL	---	FF	Array of six values defining mixing heights to be associated with the six stability categories summarized in the joint frequency function (meters)
Record type 12			
FMETEO	1-64	16A4	Format statement, including beginning and ending parenthesis, for the meteorological joint frequency function. User note: CDM format was (7X,6F7.0)

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 13*			
F(i,j,k)	---	US	Meteorological joint frequency function; i = index for stability class j = index for wind speed class k = index for wind direction
Record type 14			
FSOURC	1-64	16A4	Format statement, including beginning and ending parenthesis, for the source inventory. User note: CDM format was (F6.0,2F7.0,2F8.0,F7.0, F5.0,2F7.0,F5.0)
Record type 15†			
X	---	US	East-west coordinate of source (user units)
Y	---	US	North-south coordinate of source (user units)
TX	---	US	Width of area source (meters). Leave blank for point sources.
S1	---	US	Emission rate of pollutant 1 (g/sec)
S2	---	US	Emission rate of pollutant 2 (g/sec)
SH	---	US	Source height (meters)
D	---	US	Stack diameter (meters). Leave blank for area sources.
VS	---	US	Exit velocity (m/sec). Leave blank for area sources.
T	---	US	Stack gas temperature. Leave blank for area sources. User selected units (see record type 4).

(continued)

TABLE 15 (continued)

Record type, Variable	Column	Format	Variable description (units)
SA	---	US	Plume rise option ≤ 0, Briggs plume rise > 0, Holland's equation. Enter product of plume rise and wind speed (m^2/sec)
Record type 16			
--	---	--	This is a blank record which follows the source data. It is used to test for the end of the source data and must not be left out.
Record type 17			
FRECPT	1-64	16A4	Format statement, including beginning and ending parenthesis, for the receptors. User note: CDM format was (2F8.0,14X,I4,3X,I4,I5)
Record type 18]			
RX	---	US	East-west coordinate of the receptor (user units)
RY	---	US	North-south coordinate of the receptor (user units)
KPX9	---	US	Observed concentration of pollutant 1 at the receptor, if known ($\mu g/m^3$)
KPX10	---	US	Observed concentration of pollutant 2 at the receptor, if known ($\mu g/m^3$)
NROSE	---	US	Option for pollutant concentration roses > 0, print concentration roses ≤ 0, no concentration roses

FF = free format; US = user-specified format

* If N1636 = 16 there are 96 records of this type; if N1636 = 36 there are 216 records of this type.

† There are as many of this record type as there are sources.

] There are as many of this record type as there are receptors.

INTRICACIES OF THE DATA

Most of the input data are straightforward and typical of the kind of information required for Gaussian models. However, there are some input variables which require additional explanation to ensure proper value assignment.

Record Type 2

CDM-2.0 calculates concentrations for two pollutants in a single execution. Therefore, the user is asked to input two pollutant names, two sets of calibration constants, and two emission rates, one for each of the two pollutants modeled. In this record, the user is asked to provide two names for the pollutants. These two names, which are each four characters in length, are subsequently used in the output as labels. It is important that the order used in this record for array variable PNAME is followed for array variables CA and CB in record type 3 and variables S1 and S2 in record type 15.

Variable NSO2 informs the program which of the pollutants if any is SO_2. Within the program, SO_2 requires special processing depending on the options exercised. If NSO2 = 0, then the program assumes that SO_2 will not be run. If NSO2 = 1, then pollutant 1 is assumed to be SO_2; if NSO2 = 2, then pollutant 2 is assumed to be SO_2.

Record Type 3

AROS and PROS are alphanumeric arrays to identify the output record for the area and point concentration roses. In defining these two arrays it is important to keep in mind that area and point concentration roses are provided for both pollutants. AROS and PROS might be input as follows:

AROS(1) = A P1 PROS(1) = P P1
AROS(2) = A P2 PROS(2) = P P2

The first two characters refer to the source type (i.e., A for area and P for point) and the last two characters refer to pollutant (i.e., P1 for pollutant 1 and P2 for pollutant 2).

If the calibration feature of CDM-2.0 is not used, the value of the intercept (CA) and slope (CB) should be specified as 0 and 1, respectively. This results in the calibrated concentration identical to the computed value. Note that CA and CB are two entry arrays for the two pollutants being modeled.

Record Type 4

For point sources, CDM-2.0 allows user selection of both initial dispersion due to building effects and buoyancy-induced dispersion. The user should verify that simultaneous selection of these options is appropriate for the particular modeling situation.

Variable NDEF is the default option switch. This feature is designed as a convenience to the user with the aim of avoiding inadvertent errors in setting the options. By exercising the default option, several features are automatically set thus overriding other user-input selections. Specifics of the default option are summarized in Appendix A.

Record Types 5 and 6

The user-specified dispersion parameter scheme for area and point sources is indicated through variables KLOW and KHIGH, respectively. Table 16 lists the dispersion algorithm and its corresponding value of KLOW or KHIGH.

TABLE 16. VALUES OF KLOW OR KHIGH AND THEIR CORRESPONDING DISPERSION PARAMETER SCHEMES

KLOW or KHIGH	Dispersion parameter scheme
1	Briggs-rural (Gifford, 1976)
2	Briggs-urban (Gifford, 1976)
3	BNL (Singer and Smith, 1966)
4	Klug (Vogt, 1977)
5	St. Louis (Vogt, 1977)
6	PGCDM (Busse and Zimmerman, 1973)
7	PGSIG (Pasquill, 1961 and Gifford, 1960)

Although CDM-2.0 recognizes seven distinct stability categories, the meteorological joint frequency function is assumed to be comprised of only six classes. The specification of the values for arrays ICA and ICP is, in part, a function of the manner in which the joint frequency function is formulated, and these arrays are a function of the dispersion parameter scheme selected. In the original CDM, the PGCDM dispersion parameter scheme was employed. The urban effects were modeled by "slipping" the curves, i.e. using a curve other than that which would ordinarily be used in a rural situation. With the enhancements incorporated in CDM-2.0, one can select either to accommodate urban effects as was done in CDM or, one can select either the Briggs-urban or the St. Louis schemes. An example should clarify their use.

For this example, assume we have specified KLOW and KHIGH to be 7 (PGSIG scheme). Suppose NCC's Day-Night STAR program is used to generate the joint frequency function. This summary includes the following stability categories: A, B, C, D-day, D-night, and nighttime stable (i.e., a combination of Pasquill classes E and F). Array variables ICP and ICA would be defined as 1, 2, 3, 4, 5, and 6 for modeling a rural situation. If one wanted to account for urban effects by "slipping" the categories, as was done by CDM, then ICP would be 1, 2, 3, 5, 5, 5, and ICA would be 1, 1, 2, 3, 5, 5. However, if the joint frequency function is formulated using categories A, B, C, D, E, and F, then ICP and ICA are input as: 1, 2, 3, 5, 6, and 7 for a rural situation. Mixing height is not affected by array variables ICP and ICA since HL is linked to the six stability categories summarized in the joint frequency function.

Record Type 7

A potential error in the area source integration algorithm is radial skipover (Brubaker et al., 1977); radial skipover is illustrated in Figure 10a. In this instance, the area source size is smaller than the sampling interval, n DELR, where n = 1, 2, or 4 (see Section 5). It is easy to see that radial skipover can be minimized by keeping DELR small. However, not only is CPU time increased with decreasing DELR but also CDM-2.0 is limited presently to 100 radial arcs. Thus the use of smaller DELR may result in the termination of the radial integration due to computer storage restrictions before the far edge of the emission grid is reached with the corresponding omission of a significant part of the total area source contribution. Figure 11 gives the maximum range attainable as a function of DELR; it should be used in defining an appropriate DELR for the user's modeling range.

The easiest way to explain the emission grid is by a practical example. Suppose that an emission inventory exists with the smallest emission square 5000 feet on a side and all coordinates are given in terms of feet. In this instance, the basic emission grid square is 5000 feet on a side and thus RAT is 5000. CV is 0.3048 (i.e., 1 ft = 0.3048 m); TXX is 1524 (i.e., 5000 ft = 1524 m); and XG, YG, are in feet. Also, all source and receptor coordinates are expressed in feet (map coordinates).

Record Type 8

Another source of error in the area source integration is angular skipover. As shown in Figure 10b, the area source is skipped over by the sampling points. Obviously, the potential for angular skipover is reduced if the area source inventory is

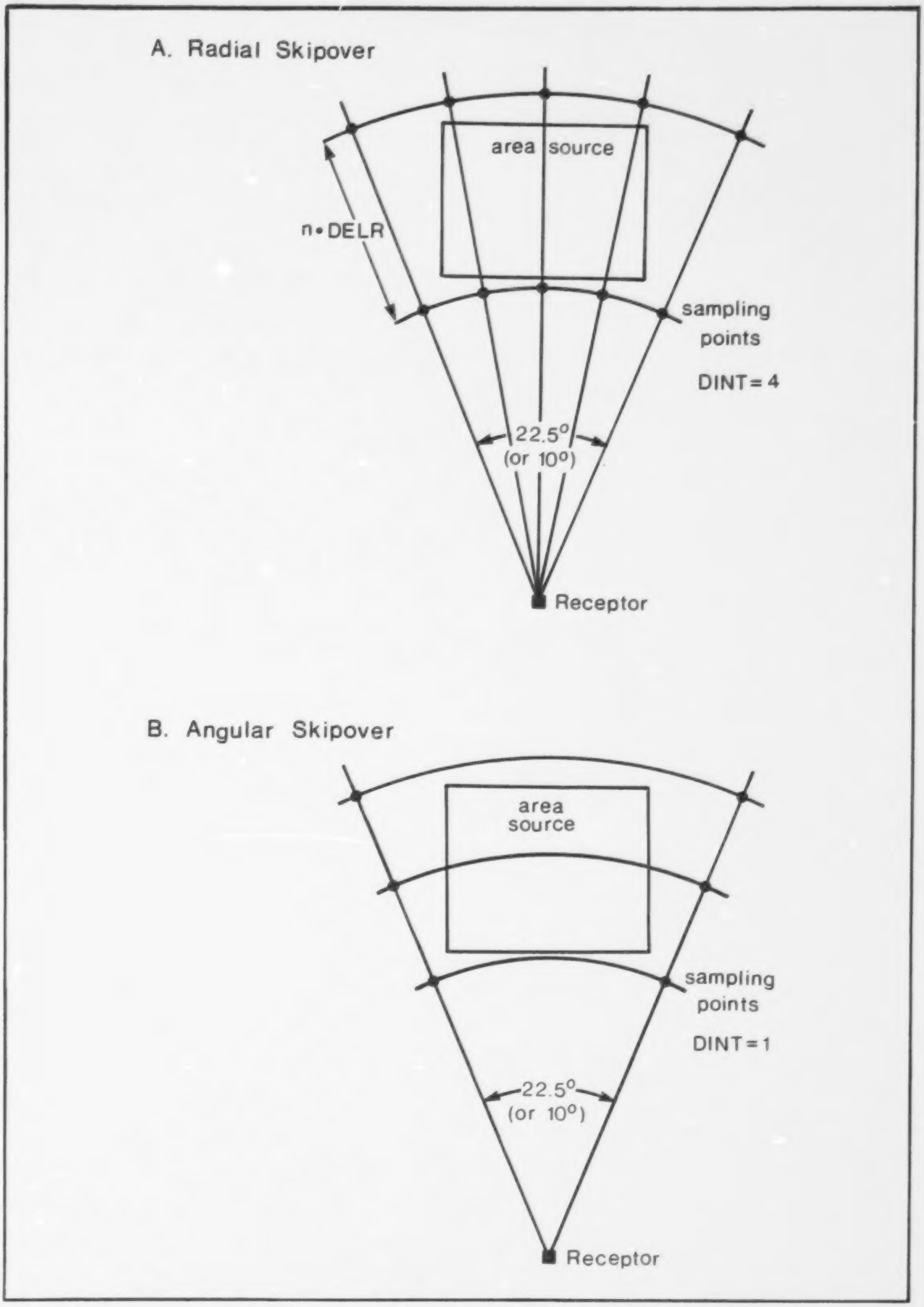

A. Radial Skipover
area source
n•DELR
sampling points
DINT=4
22.5°
(or 10°)
Receptor
B. Angular Skipover
area source
sampling points
DINT=1
22.5°
(or 10°)
Receptor

Figure 10. Radial and angular skipover (modified from Brubaker et al., 1977).

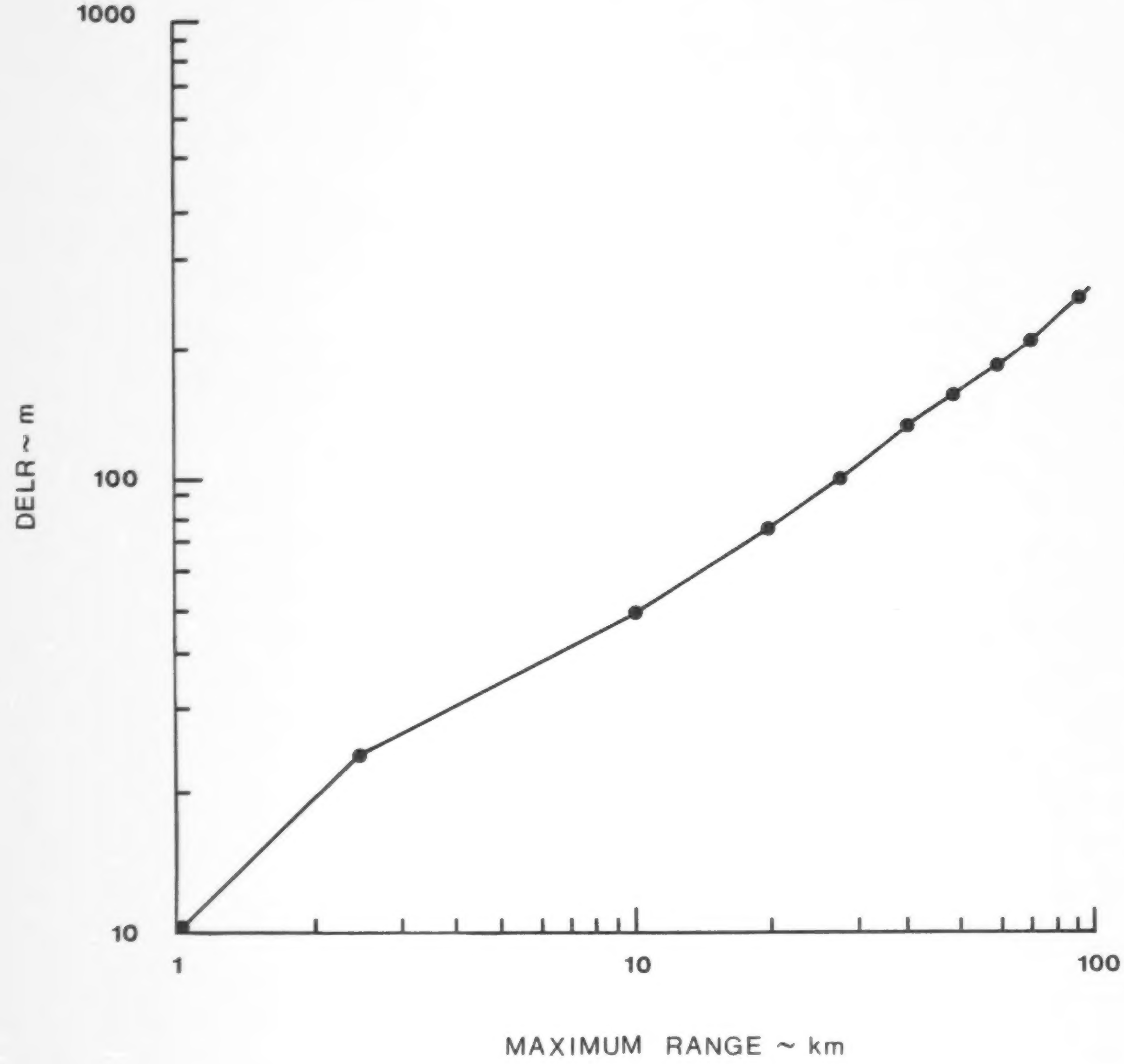


Figure 11. DELR as a function of maximum range of area source integration (modified from Brubaker et al., 1977).

described using large (say 5 km or larger) grid squares. For a detailed inventory employing area-source squares with side lengths of 1 km, Brubaker et al. (1977) suggests using DINT = 10 with a wind direction sector of 22.5° to reduce the likelihood of angular skipover. DINT = 4 is probably sufficient with a 10° wind-direction sector (i.e., N1636 = 36).

Record Type 11

HL is an array variable containing six values which define mixing heights (in meters) associated with the six stability categories summarized in the joint frequency function. The user must decide on an appropriate relationship between mixing height and stability category. One possible scheme is shown in Table 5.

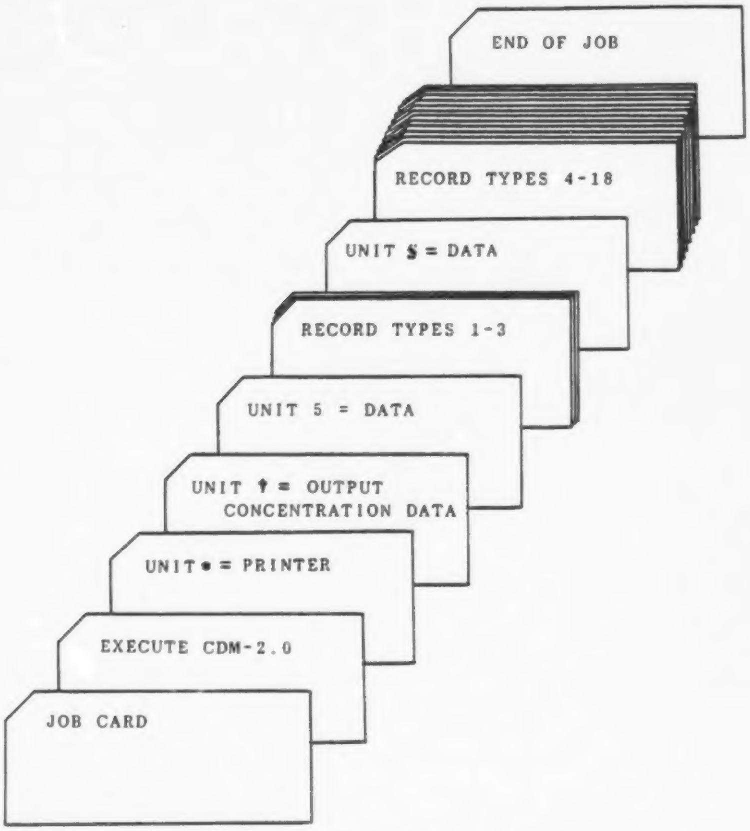
Dispersion from sources with effective release heights above the mixing height is not assumed to reach the receptors. If the mixing height is set to zero for a particular stability, then no contributions from any of the sources would occur (during that particular stability). If the user believes that unlimited mixing is the appropriate condition for a particular stability, then the mixing height (for that stability category) should be specified as a very large value (say 9999. m).

SECTION 9

EXECUTION OF THE MODEL AND SAMPLE TEST

EXECUTION

CDM-2.0 produces an error-free compile on IBM MVS and UNIVAC EXEC 8 computers with comparable execution results. A sample job stream is presented below.


END OF JOB
RECORD TYPES 4-18
UNIT § = DATA
RECORD TYPES 1-3
UNIT 5 = DATA
UNIT † = OUTPUT CONCENTRATION DATA
UNIT * = PRINTER
EXECUTE CDM-2.0
JOB CARD

* Unit number provided by user via input variable, IWR.
† Unit number provided by user via input variable, IPU.
§ Unit number provided by user via input variable, IRD.

Figure 12. Sample job stream for CDM-2.0.

A job stream for a UNIVAC EXEC 8 system might have the following form:

```
@RUN,R/R JOB-ID,ETC
@ASG,A MODELS*LOAD.
@ASG,A CONC.
@USE 8,CONC.
@XQT MODELS*LOAD.CDM2
(input records shown in Table 17)
@FIN
```

The following is a sample job stream for a typical IBM system under OS or MVS.

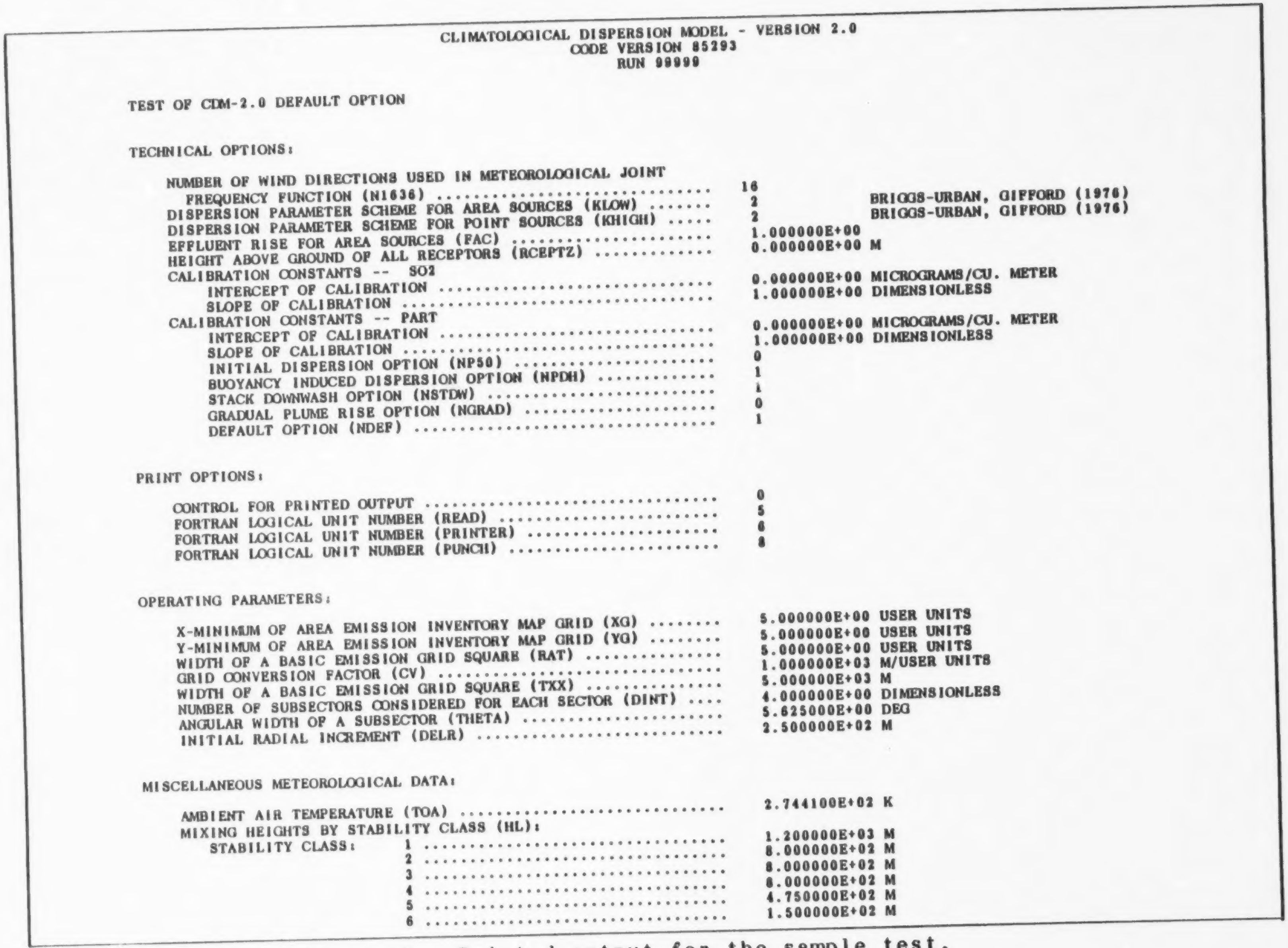
```
//JOBID     JOB  (PROJ,ACCT,OTHER),CLASS=A,TIME=1
//XCDM2     EXEC PGM=CDM2,TIME=(,10)
//STEPLIB   DD   DSN=USER.MODELS.LOAD,DISP=SHR
//FT08F001  DD   DSN=USER.CONC.DATA,DISP=SHR
//FT06F001  DD   SYSOUT=A
//FT05F001  DD   *
(input records shown in Table 17)
/*
//
```

Sample test data for model verification are given in Table 17; Figures 13 and 14 provide the output for the sample test. Users may verify the proper execution of the program by comparing their results with those given in the figures.

TABLE 17. INPUT DATA FOR THE SAMPLE TEST

```
                                                                              Record
Record                                                                         type

SAMPLE TEST OF CDM-2.0                                                           1
1    SO2PART                                                                     2
A P1A P2P P1P P299999   0    5    6    8      0.0      0.0      1.0      1.0     3
16,1,0,0,0,1.,0.,0,0                                                             4
6,1,1,2,3,4,4                                                                    5
6,1,2,3,4,4,4                                                                    6
  250.    5. 1000.    5.    5.  1.25 5000.                                       7
    4.    1.    1.   30.   30.   30.   30.   30.   30.    3.999999               8
.10,.15,.20,.25,.25,.30                                                          9
1.5,2.45872,4.4704,6.92912,9.61136,12.51712                                     10
1200.,800.,800.,800.,475.,150.                                                  11
(7X,6F7.0)                                                                      12
48 blank card images                                                            13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
       0.062500.000000.000000.000000.000000.00000                               13
32 blank card images                                                            13
(F6.0,F7.0,F7.0,F8.0,F8.0,F7.0,F5.0,F7.0,F7.0,F5.0)                             14
   5.0    5.0 10000.   4000.   4000.    20.                                     15
   5.0   15.0  5000.   1000.   1000.    20.                                     15
  10.0   15.0  5000.   1000.   1000.    20.                                     15
  15.0   15.0  5000.   1000.   1000.    20.                                     15
  15.0   10.0  5000.   1000.   1000.    20.                                     15
  15.0    5.0  5000.   1000.   1000.    20.                                     15
  12.5   12.5     0.   1000.   1000.    20.  1.0    5.0   20.0  0.0             15
1 blank card image to indicate end of source records                            16
(F8.2,F8.2,I4,I4,I5)                                                            17
     5.0     5.0   0   0    0                                                   18
     5.0    10.0   0   0    0                                                   18
     5.0    15.0   0   0    0                                                   18
     5.0    20.0   0   0    0                                                   18
    10.0     5.0   0   0    0                                                   18
    10.0    10.0   0   0    0                                                   18
    10.0    15.0   0   0    0                                                   18
    10.0    20.0   0   0    0                                                   18
    15.0     5.0   0   0    0                                                   18
    15.0    10.0   0   0    0                                                   18
    15.0    15.0   0   0    0                                                   18
    15.0    20.0   0   0    0                                                   18
    20.0     5.0   0   0    0                                                   18
    20.0    10.0   0   0    0                                                   18
    20.0    15.0   0   0    0                                                   18
    20.0    20.0   0   0    1                                                   18
```



```
                              CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                         CODE VERSION 85293
                                             RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION


TECHNICAL OPTIONS:

   NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINT
      FREQUENCY FUNCTION (N1636) ................................  16
   DISPERSION PARAMETER SCHEME FOR AREA SOURCES (KLOW) .......  2            BRIGGS-URBAN, GIFFORD (1976)
   DISPERSION PARAMETER SCHEME FOR POINT SOURCES (KHIGH) .....  2            BRIGGS-URBAN, GIFFORD (1976)
   EFFLUENT RISE FOR AREA SOURCES (FAC) ......................  1.000000E+00
   HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) .............  0.000000E+00 M
   CALIBRATION CONSTANTS --  SO2
      INTERCEPT OF CALIBRATION ...............................  0.000000E+00 MICROGRAMS/CU. METER
      SLOPE OF CALIBRATION ...................................  1.000000E+00 DIMENSIONLESS
   CALIBRATION CONSTANTS -- PART
      INTERCEPT OF CALIBRATION ...............................  0.000000E+00 MICROGRAMS/CU. METER
      SLOPE OF CALIBRATION ...................................  1.000000E+00 DIMENSIONLESS
      INITIAL DISPERSION OPTION (NP50) .......................  0
      BUOYANCY INDUCED DISPERSION OPTION (NPDH) ..............  1
      STACK DOWNWASH OPTION (NSTDW) ..........................  1
      GRADUAL PLUME RISE OPTION (NGRAD) ......................  0
      DEFAULT OPTION (NDEF) ..................................  1


PRINT OPTIONS:

   CONTROL FOR PRINTED OUTPUT ................................  0
   FORTRAN LOGICAL UNIT NUMBER (READ) ........................  5
   FORTRAN LOGICAL UNIT NUMBER (PRINTER) .....................  6
   FORTRAN LOGICAL UNIT NUMBER (PUNCH) .......................  8


OPERATING PARAMETERS:

   X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (XG) ........  5.000000E+00 USER UNITS
   Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (YG) ........  5.000000E+00 USER UNITS
   WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ...............  5.000000E+00 USER UNITS
   GRID CONVERSION FACTOR (CV) ...............................  1.000000E+03 M/USER UNITS
   WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ...............  5.000000E+03 M
   NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECTOR (DINT) ....  4.000000E+00 DIMENSIONLESS
   ANGULAR WIDTH OF A SUBSECTOR (THETA) ......................  5.625000E+00 DEG
   INITIAL RADIAL INCREMENT (DELR) ...........................  2.500000E+02 M


MISCELLANEOUS METEOROLOGICAL DATA:

   AMBIENT AIR TEMPERATURE (TOA) .............................  2.744100E+02 K
   MIXING HEIGHTS BY STABILITY CLASS (HL):
      STABILITY CLASS:     1 .................................  1.200000E+03 M
                           2 .................................  8.000000E+02 M
                           3 .................................  8.000000E+02 M
                           4 .................................  8.000000E+02 M
                           5 .................................  4.750000E+02 M
                           6 .................................  1.500000E+02 M
```

Figure 13. Printed output for the sample test.

```
                              CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                          CODE VERSION 85293
                                              RUN 99999
TEST OF CDM-2.0 DEFAULT OPTION

MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):

   CENTRAL WIND SPEED OF THE SIX WIND SPEED CLASSES (U):
      WIND SPEED CLASS:    1 ................................    1.500000E+00 M/SEC
                           2 ................................    2.458720E+00 M/SEC
                           3 ................................    4.470400E+00 M/SEC
                           4 ................................    6.929120E+00 M/SEC
                           5 ................................    9.611360E+00 M/SEC
                           6 ................................    1.251712E+01 M/SEC

   EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):
      STABILITY CLASS:     1 ................................    1.000000E-01 DIMENSIONLESS
                           2 ................................    1.500000E-01 DIMENSIONLESS
                           3 ................................    2.000000E-01 DIMENSIONLESS
                           4 ................................    2.500000E-01 DIMENSIONLESS
                           5 ................................    2.500000E-01 DIMENSIONLESS
                           6 ................................    3.000000E-01 DIMENSIONLESS


SOURCE DATA:

   POLLUTANTS TO BE MODELED .............................     SO2 & PART
   DECAY HALF-LIFE FOR SO2 (GB(1)) ......................    4.000000E+00 HR
   DECAY HALF-LIFE FOR PART (GB(2)) .....................    9.999990E+05 HR
   DAYTIME EMISSION WEIGHT FACTOR (YD) ..................    1.000000E+00 DIMENSIONLESS
   NIGHTTIME EMISSION WEIGHT FACTOR (YN) ................    1.000000E+00 DIMENSIONLESS
   INITIAL SIGMA-Z FOR AREA SOURCES (SZA):
      STABILITY CLASS:     1 ................................    3.000000E+01 M
                           2 ................................    3.000000E+01 M
                           3 ................................    3.000000E+01 M
                           4 ................................    3.000000E+01 M
                           5 ................................    3.000000E+01 M
                           6 ................................    3.000000E+01 M

DISPERSION CURVE USED FOR EACH STABILITY CLASS
  STABILITY        POINT          AREA
    CLASS         SOURCES        SOURCES
      1              A              A
      2              B              B
      3              C              C
      4              D1             D1
      5              D2             D2
      6              E              E
```

Figure 13. (continued).

```
                        CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                  CODE VERSION 85293
                                      RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

                        METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 1                                  WIND SPEED CLASS

   WIND DIRECTION    SECTOR        1          2          3          4          5          6

        N              1       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNE            2       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NE             3       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ENE            4       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        E              5       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ESE            6       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SE             7       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSE            8       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        S              9       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSW           10       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SW            11       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WSW           12       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        W             13       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WNW           14       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NW            15       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNW           16       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000

                                           COMPUTED MEAN SPEED =  0.00 M/SEC

STABILITY CLASS 2                                  WIND SPEED CLASS

   WIND DIRECTION    SECTOR        1          2          3          4          5          6

        N              1       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNE            2       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NE             3       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ENE            4       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        E              5       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ESE            6       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SE             7       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSE            8       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        S              9       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSW           10       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SW            11       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WSW           12       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        W             13       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WNW           14       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NW            15       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNW           16       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000

                                           COMPUTED MEAN SPEED =  0.00 M/SEC
```

Figure 13. (continued).

```
                    CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                CODE VERSION 85293
                                    RUN 99999
TEST OF CDM-2.0 DEFAULT OPTION


                         METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 3
                                                     WIND SPEED CLASS
    WIND DIRECTION    SECTOR        1         2         3         4         5         6

         N               1      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         NNE             2      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         NE              3      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         ENE             4      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         E               5      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         ESE             6      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         SE              7      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         SSE             8      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         S               9      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         SSW            10      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         SW             11      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         WSW            12      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         W              13      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         WNW            14      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         NW             15      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
         NNW            16      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000

                                           COMPUTED MEAN SPEED =   0.00 M/SEC

STABILITY CLASS 4
                                                     WIND SPEED CLASS
    WIND DIRECTION    SECTOR        1         2         3         4         5         6

         N               1      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         NNE             2      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         NE              3      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         ENE             4      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         E               5      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         ESE             6      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         SE              7      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         SSE             8      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         S               9      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         SSW            10      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         SW             11      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         WSW            12      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         W              13      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         WNW            14      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         NW             15      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000
         NNW            16      0.062500  0.000000  0.000000  0.000000  0.000000  0.000000

                                           COMPUTED MEAN SPEED =   1.50 M/SEC
```

Figure 13. (continued).

```
                   CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                              CODE VERSION 85293
                                  RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

                      METEOROLOGICAL JOINT FREQUENCY FUNCTION

                                              WIND SPEED CLASS
STABILITY CLASS 5
                                  1          2          3          4          5          6
  WIND DIRECTION   SECTOR
                                                        0.000000   0.000000   0.000000   0.000000
      N              1      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NNE            2      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NE             3      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      ENE            4      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      E              5      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      ESE            6      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SE             7      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SSE            8      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      S              9      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SSW           10      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SW            11      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      WSW           12      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      W             13      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      WNW           14      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NW            15      0.000000   0.000000   0.000000   0.000000   0.000000
      NNW           16      0.000000   0.000000
                                          COMPUTED MEAN SPEED =  0.00 M/SEC

                                              WIND SPEED CLASS
STABILITY CLASS 6
                                  1          2          3          4          5          6
  WIND DIRECTION   SECTOR
                                                        0.000000   0.000000   0.000000   0.000000
      N              1      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NNE            2      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NE             3      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      ENE            4      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      E              5      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      ESE            6      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SE             7      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SSE            8      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      S              9      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SSW           10      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      SW            11      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      WSW           12      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      W             13      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      WNW           14      0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
      NW            15      0.000000   0.000000   0.000000   0.000000   0.000000
      NNW           16      0.000000   0.000000
                                          COMPUTED MEAN SPEED =  0.00 M/SEC
```

Figure 13. (continued).

```
                      CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                  CODE VERSION 85293
                                      RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

                                     AREA AND POINT SOURCE INVENTORY

                                                                        STACK    STACK      OPTIONAL
                          WIDTH OF    ----EMISSION RATE----   SOURCE   STACK    EXIT     GAS      PLUME RISE
   X MAP       Y MAP     GRID SQUARE     SO2         PART     HEIGHT   DIAM     SPEED    TEMP     COEFFICIENT
COORDINATE  COORDINATE      (M)        (G/SEC)     (G/SEC)     (M)      (M)    (M/SEC)  (DEG C)   (M**2/SEC)

    5.00        5.00      10000.      4000.00     4000.00     20.00    0.00     0.00      0.0        0.00
    5.00       15.00       5000.      1000.00     1000.00     20.00    0.00     0.00      0.0        0.00
   10.00       15.00       5000.      1000.00     1000.00     20.00    0.00     0.00      0.0        0.00
   15.00       15.00       5000.      1000.00     1000.00     20.00    0.00     0.00      0.0        0.00
   15.00       10.00       5000.      1000.00     1000.00     20.00    0.00     0.00      0.0        0.00
   15.00        5.00       5000.      1000.00     1000.00     20.00    0.00     0.00      0.0        0.00
   12.50       12.50          0.      1000.00     1000.00     20.00    1.00     5.00     20.0        0.00

        6 AREA SOURCES.        1 POINT SOURCES.
```

Figure 13. (continued).

```
                      CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                CODE VERSION 85293
                                    RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

                         CONCENTRATIONS (MICROGRAMS/CU. METER)

                     AREA  SOURCES    POINT  SOURCES    -----TOTAL-----    --CALIBRATED--    ---OBSERVED---
 X COORD   Y COORD    SO2     PART      SO2     PART      SO2      PART      SO2     PART      SO2      PART

    5.00      5.00  235.9    264.5      7.9     10.5    243.8     275.0    243.8    275.0        0         0
    5.00     10.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
    5.00     15.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
    5.00     20.00  235.9    264.5      7.9     10.5    243.8     275.0    243.8    275.0        0         0
   10.00      5.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
   10.00     10.00  542.7    580.3     52.9     58.2    595.6     638.5    595.6    638.5        0         0
   10.00     15.00  542.7    580.3     52.9     58.2    595.6     638.5    595.6    638.5        0         0
   10.00     20.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
   15.00      5.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
   15.00     10.00  542.7    580.3     52.9     58.2    595.6     638.5    595.6    638.5        0         0
   15.00     15.00  542.7    580.3     52.9     58.2    595.6     638.5    595.6    638.5        0         0
   15.00     20.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
   20.00      5.00  235.9    264.5      7.9     10.5    243.8     275.0    243.8    275.0        0         0
   20.00     10.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
   20.00     15.00  342.7    374.1     12.1     15.0    354.8     389.1    354.8    389.1        0         0
```

Figure 13. (continued).

```
                          CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                      CODE VERSION 85293
                                          RUN 99999

TEST OF CDM-2.0 DEFAULT OPTION

                                 CONCENTRATIONS (MICROGRAMS/CU. METER)

                       AREA  SOURCES     POINT  SOURCES    -----TOTAL-----    --CALIBRATED--    ---OBSERVED---
X COORD   Y COORD       SO2     PART       SO2     PART      SO2      PART      SO2     PART      SO2     PART
  20.00     20.00     235.9    264.5       7.9     10.5    243.8     275.0    243.8    275.0        0        0

**************************************** AVERAGE CONCENTRATIONS BY STABILITY ****************************************

                      TYPE OF     -------------STABILITY CATEGORY-------------
            POLLUTANT SOURCE        1       2       3       4       5       6
             1 ( SO2) AREA        0.0     0.0     0.0   235.9     0.0     0.0
             1 ( SO2) POINT       0.0     0.0     0.0     7.9     0.0     0.0

             2 (PART) AREA        0.0     0.0     0.0   264.5     0.0     0.0
             2 (PART) POINT       0.0     0.0     0.0    10.5     0.0     0.0

**************************************** AREA ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
       1          4     4     4     4     4     4     4     4    29    45    48    45    29     4     4     4
       2          4     4     4     4     4     4     4     4    32    51    57    51    32     4     4     4

**************************************** POINT ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
       1          0     0     0     0     0     0     0     0     0     0     8     0     0     0     0     0
       2          0     0     0     0     0     0     0     0     0     0    11     0     0     0     0     0
****************************************************************************************************************
```

Figure 13. (continued).

```
          5.00      5.0099999I 236 264   8  10 244 275 244 275   0   0
          5.00     10.0099999I 343 374  12  15 355 389 355 389   0   0
          5.00     15.0099999I 343 374  12  15 355 389 355 389   0   0
          5.00     20.0099999I 236 264   8  10 244 275 244 275   0   0
         10.00      5.0099999I 343 374  12  15 355 389 355 389   0   0
         10.00     10.0099999I 543 580  53  58 596 638 596 638   0   0
         10.00     15.0099999I 543 580  53  58 596 638 244 275   0   0
         10.00     20.0099999I 343 374  12  15 355 389 355 389   0   0
         15.00      5.0099999I 343 374  12  15 355 389 355 389   0   0
         15.00     10.0099999I 543 580  53  58 596 638 596 638   0   0
         15.00     15.0099999I 543 580  53  58 596 638 596 638   0   0
         15.00     20.0099999I 343 374  12  15 355 389 355 389   0   0
         20.00      5.0099999I 236 264   8  10 244 275 244 275   0   0
         20.00     10.0099999I 343 374  12  15 355 389 355 389   0   0
         20.00     15.0099999I 344 374  12  15 355 389 355 389   0   0
A P1      0.0      0.0      0.0  235.9     0.0      0.0     2000      2000
P P1      0.0      0.0      0.0    7.9     0.0      0.0     2000      2000
A P2      0.0      0.0      0.0  264.5     0.0      0.0     2000      2000
P P2      0.0      0.0      0.2   10.5     0.0      0.0     2000      2000
A P1      4     4     4     4     4     4     4     4    2000    2000
A P1     29    45    48    45    29     4     4     4    2000    2000
A P2      4     4     4     4     4     4     4     4    2000    2000
A P2     32    51    57    51    32     4     4     4    2000    2000
P P1      0     0     0     0     0     0     0     0    2000    2000
P P1      0     0     8     0     0     0     0     0    2000    2000
P P2      0     0     0     0     0     0     0     0    2000    2000
P P2      0     0    11     0     0     0     0     0    2000    2000
```

Figure 14. Card image output for the sample test.

ERROR MESSAGES AND REMEDIAL ACTION

CDM-2.0 can generate nine error messages and two warning messages. An error message results in program termination while a warning message allows execution to continue. Table 18 lists each message, along with its description and suggested corrective action.

TABLE 18. CDM-2.0 ERROR/WARNING MESSAGES AND CORRECTIVE ACTION

MESSAGE (1):	*** VALID VALUES FOR NSO2 ARE 0, 1, OR 2. *** USER INPUT NSO2 = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	NSO_2 must be set to 0, 1, or 2. Any other value will result in program termination.
ACTION:	Modify input stream so that NSO_2 is equal to 0, 1, or 2 and resubmit the job.
MESSAGE (1):	*** VALID VALUES FOR N1636 ARE 16 OR 36. *** USER INPUT N1636 = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	The meteorological joint frequency function can only consist of 16 or 36 wind-direction sectors. The user tried to input a value different from 16 or 36.
ACTION:	Modify the input stream so that N1636 is equal to 16 or 36 and make sure that the number of wind direction sectors in the joint frequency function agrees with the value given by N1636.
MESSAGE (1):	*** VALID VALUES FOR FAC RANGE FROM 0 TO 1. *** USER INPUT FAC = xxx.xx *** EXECUTION TERMINATED.
DESCRIPTION:	FAC must be between 0 and 1, inclusive. The user tried to input a value outside that range.

(continued)

TABLE 18 (continued)

ACTION:	Modify input stream so that FAC is between 0 and 1, inclusive.
MESSAGE (1):	*** VALID VALUES OF KLOW RANGE FROM 1 TO 7. *** USER TRIED TO INPUT KLOW = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	KLOW must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that KLOW is between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR ICA RANGE FROM 1 TO 7. *** USER TRIED TO INPUT ICA(i) = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	Values in the array ICA must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that all the values in the array ICA are between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR KHIGH RANGE FROM 1 TO 7. *** USER INPUT KHIGH = nnnn *** EXECUTION TERMINATED.
DESCRIPTION:	KHIGH must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that KHIGH is between 1 and 7, inclusive.
MESSAGE (1):	*** VALID VALUES FOR ICP RANGE FROM 1 TO 7. *** USER INPUT ICP(i) = nnnn *** EXECUTION TERMINATED.

(continued)

TABLE 18 (continued)

DESCRIPTION:	Values in the array ICP must be between 1 and 7, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that all the values in the array ICP are between 1 and 7, inclusive.
MESSAGE (1):	*** THE PRODUCT OF RAT AND CV MUST EQUAL TXX. *** THE VALUES PROVIDED BY THE USER DO NOT CONFORM TO THIS RELATIONSHIP. *** EXECUTION TERMINATED.
DESCRIPTION:	The quantities RAT, CV, and TXX are related by the following equation: TXX = RAT·CV. However the user-supplied quantities do not relate in the prescribed manner.
ACTION:	Modify input stream so that the quantities meet the above-mentioned relationship.
MESSAGE (1):	*** VALID VALUES FOR DINT RANGE FROM 2 TO 20. *** USER INPUT DINT = xxx.x *** EXECUTION TERMINATED.
DESCRIPTION:	DINT must be between 2 and 20, inclusive. The user tried to input a value outside that range.
ACTION:	Modify input stream so that DINT is between 2 and 20, inclusive.
MESSAGE (2):	NOTE: AREA SOURCE WITH X COORD xxxxxxx.xx AND Y COORD yyyyyyy.yy VIOLATES AREA SOURCE ARRAY LIMITS. AREA SOURCES MUST LIE ENTIRELY WITHIN A xxxxxxxx.xx BY xxxxxxxx.xx METER SQUARE WITH SOUTHWEST CORNER AT THE USER-DEFINED ORIGIN (XG,YG). THIS SOURCE WILL NOT BE INCLUDED IN THIS CALCULATION.

(continued)

TABLE 18 (continued)

DESCRIPTION:	The area source emission grid may not be larger than 50 grid squares in either the x or the y direction, this limit being determined by the dimensions of various arrays defined within the computer program. This limit, together with the user-specified size of a basic grid square (TXX), imposes a limit to the total size of the emission grid. A test is made to see that each area source falls within the boundaries of the grid. It was determined the area source mentioned in the warning message lies partially or wholly outside the grid boundaries. As indicated in the message, the calculation proceeds but the area source in violation is omitted from the inventory.
ACTION:	Adjust the location of the origin (XG,YG) or the size of the basic emission grid square (TXX) such that all area sources are within the boundaries of the grid. Alternatively, the dimensions could be appropriately increased to accommodate the area source inventory.
MESSAGE (2):	WARNING: MORE THAN 100 ARCS ARE REQUIRED FOR CALCULATION OF AREA CONTRIBUTION. AREA SOURCES BEYOND xxx.x KM ARE NOT INCLUDED IN THIS CALCULATION.
DESCRIPTION:	As discussed in Section 5, the area source algorithm evaluates the average emission rate on a series of arcs centered on the receptor of interest. No more than 100 arcs are used, this limit, together with the user-supplied radial integration step, DELR, imposes an upper limit to the distance to which the area source calculations

(continued)

TABLE 18 (continued)

	are taken. If there are area sources beyond this range, they are not included in the calculations.
ACTION:	Guidance on choosing DELR to avoid this problem is provided in Figure 11. The integration step, DELR, should be modified such that all area sources are included in the calculation. Alternatively, the user could increase the number of integration steps allowed.

(1) Error message -- execution terminated.

(2) Warning message -- execution continues.

SECTION 10

INTERPRETATION OF OUTPUT

The input stream and output listing of the example problem in Section 6 are presented here. The reader is referred to the earlier section for the physical description of the problem. Intricacies of the input data are discussed and the output listing is annotated for ease of interpretation.

Table 19 lists the input data for the example problem. Note that the PGCDM dispersion scheme (KLOW = KHIGH = 6) was chosen for this example. Arrays ICP and ICA were so defined to simulate the more unstable conditions of the urban atmosphere. As shown in Figure 15, RAT (the basic emission grid square in user units) is 5 km; thus TXX = 5000 m and CV = 1000. The coordinates of the southwest corner of the emission grid (XG, YG) is also given in Figure 15. As indicated in Table 19, receptors are combined into two groups: those in which NROSE $\leq$ 0 and those in which NROSE > 0. Output volume is reduced in this manner.

The printed output of CDM-2.0 consists of four parts: set-up information, meteorology, source inventory, and concentration results. The set-up information, meteorology, and source inventory are optionally provided (see variable NLIST of record type 5 in Table 15). Abridged output from the example problem is given in Figure 16; output in card image form is shown in Table 20. The format of the card image output is given in Table 21 for ease of interpretation.

TABLE 19. INPUT DATA FOR THE EXAMPLE PROBLEM.

```
                                                                                 Record
Record                                                                             type

AQDM TEST CITY                                                                        1
1    SO2PART                                                                          2
A P1A P2P P1P P2  100     0     5     6     8       0.0       0.0       1.0       1.0 3
16,1,0,0,0,1.,0.,0,0                                                                  4
6,1,1,2,3,4,4                                                                         5
6,1,2,3,4,4,4                                                                         6
  100.     5. 1000. 562.54387.5    15. 5000.                                          7
   10.     1.     1.    30.    30.    30.    30.    30.    30.999999999999            8
0.1,0.15,0.2,0.25,0.25,0.3                                                            9
1.5,2.45872,4.4704,6.92912,9.61136,12.51712                                          10
1500.,1000.,1000.,1000.,550.,100.                                                    11
(9X,6F9.0)                                                                           12
16 blank card images                                                                 13
         .000500  .000500  .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .0       .000500  .0       .0       .0       .0                             13
         .000500  .0       .0       .0       .0       .0                             13
         .000900  .000500  .000500  .0       .0       .0                             13
         .000900  .0       .0       .0       .0       .0                             13
         .000900  .000500  .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .000900  .0       .0       .0       .0       .0                             13
         .0       .000500  .0       .0       .0       .0                             13
         .000500  .0       .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .0       .0       .0       .0       .0       .0                             13
         .000500  .0       .003200  .0       .0       .0                             13
         .0       .000500  .000900  .0       .0       .0                             13
         .0       .0       .000900  .0       .0       .0                             13
         .000900  .000900  .004600  .0       .0       .0                             13
         .001800  .002800  .004100  .000500  .0       .0                             13
         .0       .003700  .004600  .0       .0       .0                             13
         .001400  .003200  .002800  .0       .0       .0                             13
         .0       .002800  .000900  .0       .0       .0                             13
         .0       .000900  .000900  .0       .0       .0                             13
         .0       .001800  .000900  .0       .0       .0                             13
         .0       .001800  .000900  .0       .0       .0                             13
         .000500  .001400  .000900  .0       .0       .0                             13
         .0       .001400  .000900  .0       .0       .0                             13
         .000500  .000500  .000900  .0       .0       .0                             13
         .0       .000900  .000500  .0       .0       .0                             13
         .0       .001400  .001400  .0       .0       .0                             13
         .0       .001080  .031560  .022980  .002220  .0                             13
         .0       .000540  .008040  .009420  .001680  .0                             13
         .0       .000540  .006360  .008880  .000300  .0                             13
         .0       .002220  .006360  .006360  .000300  .0                             13
         .0       .003360  .008880  .008280  .003300  .000840                        13
         .0       .001680  .006060  .030420  .006660  .000840                        13
         .0       .000840  .013020  .024600  .003060  .000300                        13
         .0       .001080  .010500  .014640  .001680  .0                             13
         .0       .000300  .008880  .018000  .001380  .0                             13
         .0       .000840  .005280  .005280  .0       .0                             13
         .0       .001080  .001080  .0       .0       .0                             13
         .0       .000540  .005280  .000300  .0       .0                             13
         .0       .002460  .007740  .004140  .0       .0                             13
         .0       .002220  .009420  .006660  .001080  .0                             13
         .0       .001380  .014640  .009660  .001680  .0                             13
         .0       .001680  .018000  .019620  .001380  .0                             13
         .0       .000720  .021040  .015320  .001480  .0                             13
         .0       .000360  .005360  .006280  .001120  .0                             13
```

(continued)

TABLE 19. (continued)

```
Record                                                                          Record
                                                                                 type
          .0        .000360   .004240   .005920   .000200   .0                    13
          .0        .001480   .004240   .004240   .000200   .0                    13
          .0        .002240   .005920   .005520   .002200   .000560               13
          .0        .001120   .004040   .020280   .004440   .000560               13
          .0        .000560   .008680   .016400   .002040   .000200               13
          .0        .000720   .007000   .009760   .001120   .0                    13
          .0        .000200   .005920   .012000   .000920   .0                    13
          .0        .000560   .003520   .003520   .0        .0                    13
          .0        .000720   .000720   .0        .0        .0                    13
          .0        .000360   .003520   .000200   .0        .0                    13
          .0        .001640   .005160   .002760   .0        .0                    13
          .0        .001480   .006280   .004440   .000720   .0                    13
          .0        .000920   .009760   .006440   .001120   .0                    13
          .0        .001120   .012000   .013080   .000920   .0                    13
          .005100   .012400   .021200   .0        .0        .0                    13
          .000500   .002800   .004600   .0        .0        .0                    13
          .000900   .005100   .002800   .0        .0        .0                    13
          .003200   .007800   .004100   .0        .0        .0                    13
          .010600   .016100   .005500   .0        .0        .0                    13
          .005500   .016100   .012400   .0        .0        .0                    13
          .001400   .006900   .004600   .0        .0        .0                    13
          .000900   .005100   .005100   .0        .0        .0                    13
          .002200   .004600   .002300   .0        .0        .0                    13
          .005100   .006500   .0        .0        .0        .0                    13
          .000900   .003700   .0        .0        .0        .0                    13
          .001800   .003700   .0        .0        .0        .0                    13
          .001800   .006500   .000500   .0        .0        .0                    13
          .005500   .012000   .003700   .0        .0        .0                    13
          .008800   .011100   .003700   .0        .0        .0                    13
          .003200   .011500   .006900   .0        .0        .0                    13
(F6.0,2F7.0,2F8.0,F7.0,F5.0,2F7.0,F5.0)                                           14
 568.5 4403.4          1365.00  527.63   150.                      .0001          15
 584.2 4391.6          1580.36  789.6     90.  8.7    15.2   149.                 15
 577.0 4401.1           221.76   34.13    30.   .7    17.8   515.                 15
 574.1 4401.5           110.25   54.08    23.  1.4    15.2   260.                 15
 562.5 4402.5  5000.       1.37    1.68                                           15
 567.5 4402.5  5000.       1.26    1.79                                           15
 572.5 4402.5  5000.       5.25    3.99   10.                                     15
 577.5 4402.5  5000.       1.47   13.13                                           15
 582.5 4402.5  5000.       1.2     1.58                                           15
 562.5 4397.5  5000.       2.62    1.47   10.           To reduce length          15
 567.5 4392.5 10000.      32.66   21.11   15.           of output listing,        15
 577.5 4397.5  5000.       5.46    3.99   10.           receptors should be       15
 582.5 4397.5  5000.       6.62    5.78   10.           combined into two         15
 562.5 4392.5  5000.       2.63    1.16   10.           groups - those in         15
 577.5 4392.5  5000.       7.88    5.15   20.           which NROSE ≤ 0           15
 582.5 4392.5  5000.       5.25    3.68   10.           and those in              15
 562.5 4387.5  5000.       2.73    1.37                 which NROSE > 0.          15
 567.5 4387.5  5000.       2.42    1.89   10.                                     15
 572.5 4387.5  5000.       5.36    4.10   10.                                     15
 577.5 4387.5  5000.       5.57    3.89   10.                                     15
 582.5 4387.5  5000.       2.84    1.47   10.                                     15
1 blank card image to indicate end of source records                              16
(2F8.2,14X,I4,3X,I4,I5)                                                           17
   570.0  4393.2                  12      8                                       18
   573.9  4388.9                  14     11      )  NROSE ≤ 0                     18
   572.4  4402.2                  50     26      }                                18
   579.0  4394.0                  20      8      )                                18
   583.0  4399.2                  16      7                                       18
   562.0  4395.7                  10      6    1 )                                18
   566.1  4400.0                  18     10    1 }  NROSE > 0                     18
   572.5  4396.7                          9    1 )                                18
   577.5  4397.5                               1                                  18
   576.0  4403.0                               1                                  18
```

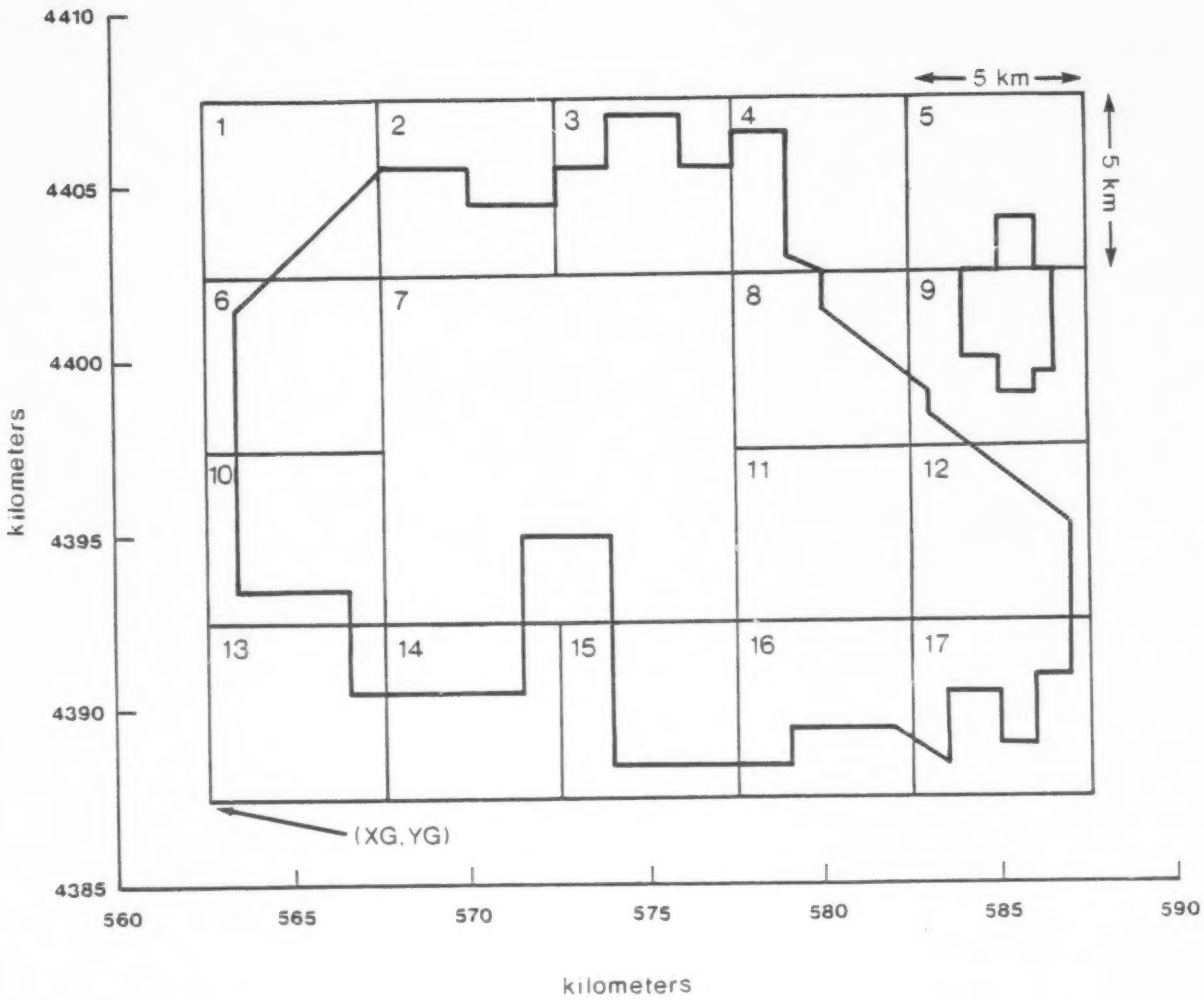

4410
4405
4400
4395
4390
4385
kilometers
560
565
570
575
580
585
590
kilometers
5 km
5 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
(XG, YG)

Figure 15. Annotated Test City map (modified from Brubaker et al., 1977).

```
                                   CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0                        SET-UP INFORMATION
                                           CODE VERSION 85267
                                               RUN   100

AQDM TEST CITY   <-- Run title

TECHNICAL OPTIONS:

    NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINT
      FREQUENCY FUNCTION (N1636) ...............................  16
    DISPERSION PARAMETER SCHEME FOR AREA SOURCES (KLOW) .........  6             PGCDM, BUSSE & ZIMMERMAN (1973)
    DISPERSION PARAMETER SCHEME FOR POINT SOURCES (KHIGH) .......  6             PGCDM, BUSSE & ZIMMERMAN (1973)
    EFFLUENT RISE FOR AREA SOURCES (FAC) ........................  1.000000E+00
    HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) ...............  0.000000E+00 M
    CALIBRATION CONSTANTS --  SO2
        INTERCEPT OF CALIBRATION ................................  0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ....................................  1.000000E+00 DIMENSIONLESS
    CALIBRATION CONSTANTS -- PART
        INTERCEPT OF CALIBRATION ................................  0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ....................................  1.000000E+00 DIMENSIONLESS
        INITIAL DISPERSION OPTION (NPSO) ........................  1 }
        BUOYANCY INDUCED DISPERSION OPTION (NPDH) ...............  0 }  Status of initial dispersion,
        STACK DOWNWASH OPTION (NSTDW) ...........................  0 }  buoyancy-induced dispersion,
        GRADUAL PLUME RISE OPTION (NGRAD) .......................  0 }  and stack downwash options.
        DEFAULT OPTION (NDEF) ...................................  0 }


PRINT OPTIONS:                                            NLIST
                                                              \
     CONTROL FOR PRINTED OUTPUT ..............................--> 0       Since NLIST = 0, set-up information
     FORTRAN LOGICAL UNIT NUMBER (READ) .........................  5       is echoed for verification.  When
     FORTRAN LOGICAL UNIT NUMBER (PRINTER) ......................  6       NLIST < 0, this page and following
     FORTRAN LOGICAL UNIT NUMBER (PUNCH) ........................  8       page are not printed.

OPERATING PARAMETERS:

     X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (XG) .........  5.625000E+02 USER UNITS
     Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (YG) .........  4.387500E+03 USER UNITS
     WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ................  5.000000E+00 USER UNITS
     GRID CONVERSION FACTOR (CV) ................................  1.000000E+03 M/USER UNITS
     WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ................  5.000000E+03 M
     NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECTOR (DINT) .....  1.000000E+01 DIMENSIONLESS
     ANGULAR WIDTH OF A SUBSECTOR (THETA) .......................  2.250000E+00 DEG
     INITIAL RADIAL INCREMENT (DELR) ............................  1.000000E+02 M


MISCELLANEOUS METEOROLOGICAL DATA:

     AMBIENT AIR TEMPERATURE (TOA) ..............................  2.881600E+02 K
     MIXING HEIGHTS BY STABILITY CLASS (HL):
        STABILITY CLASS:     1 ..................................  1.500000E+03 M
                             2 ..................................  1.000000E+03 M
                             3 ..................................  1.000000E+03 M
                             4 ..................................  1.000000E+03 M
                             5 ..................................  5.500000E+02 M
                             6 ..................................  1.000000E+02 M
```

Figure 16. Printed output for the example problem.

SET-UP INFORMATION (continued)

```
                         CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                       CODE VERSION 85267
                                          RUN   100

AQDM TEST CITY ←——Run title included on every page of listing

MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):

  CENTRAL WIND SPEED OF THE SIX WIND SPEED CLASSES (U):
      WIND SPEED CLASS:  1 ................................   1.500000E+00 M/SEC
                         2 ................................   2.458720E+00 M/SEC
                         3 ................................   4.470400E+00 M/SEC
                         4 ................................   6.929120E+00 M/SEC
                         5 ................................   9.611360E+00 M/SEC
                         6 ................................   1.251712E+01 M/SEC

  EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):
      STABILITY CLASS:   1 ................................   1.000000E-01 DIMENSIONLESS
                         2 ................................   1.500000E-01 DIMENSIONLESS
                         3 ................................   2.000000E-01 DIMENSIONLESS
                         4 ................................   2.500000E-01 DIMENSIONLESS
                         5 ................................   2.500000E-01 DIMENSIONLESS
                         6 ................................   3.000000E-01 DIMENSIONLESS


SOURCE DATA:

  POLLUTANTS TO BE MODELED ................................    SO2 & PART
  DECAY HALF-LIFE FOR SO2 (GB(1)) .........................   9.999990E+05 HR
  DECAY HALF-LIFE FOR PART (GB(2)) ........................   9.999990E+05 HR
  DAYTIME EMISSION WEIGHT FACTOR (YD) .....................   1.000000E+00 DIMENSIONLESS
  NIGHTTIME EMISSION WEIGHT FACTOR (YN) ...................   1.000000E+00 DIMENSIONLESS
  INITIAL SIGMA-Z FOR AREA SOURCES (SZA):
      STABILITY CLASS:   1 ................................   3.000000E+01 M
                         2 ................................   3.000000E+01 M
                         3 ................................   3.000000E+01 M
                         4 ................................   3.000000E+01 M
                         5 ................................   3.000000E+01 M
                         6 ................................   3.000000E+01 M

DISPERSION CURVE USED FOR EACH STABILTY CLASS
  STABILITY       POINT        AREA
    CLASS        SOURCES      SOURCES
      1             A            A
      2             B            A
      3             C            B
      4             D1           C
      5             D1           D1
      6             D1           D1
```

Figure 16. (continued).

TABLE 19. INPUT DATA FOR THE EXAMPLE PROBLEM.

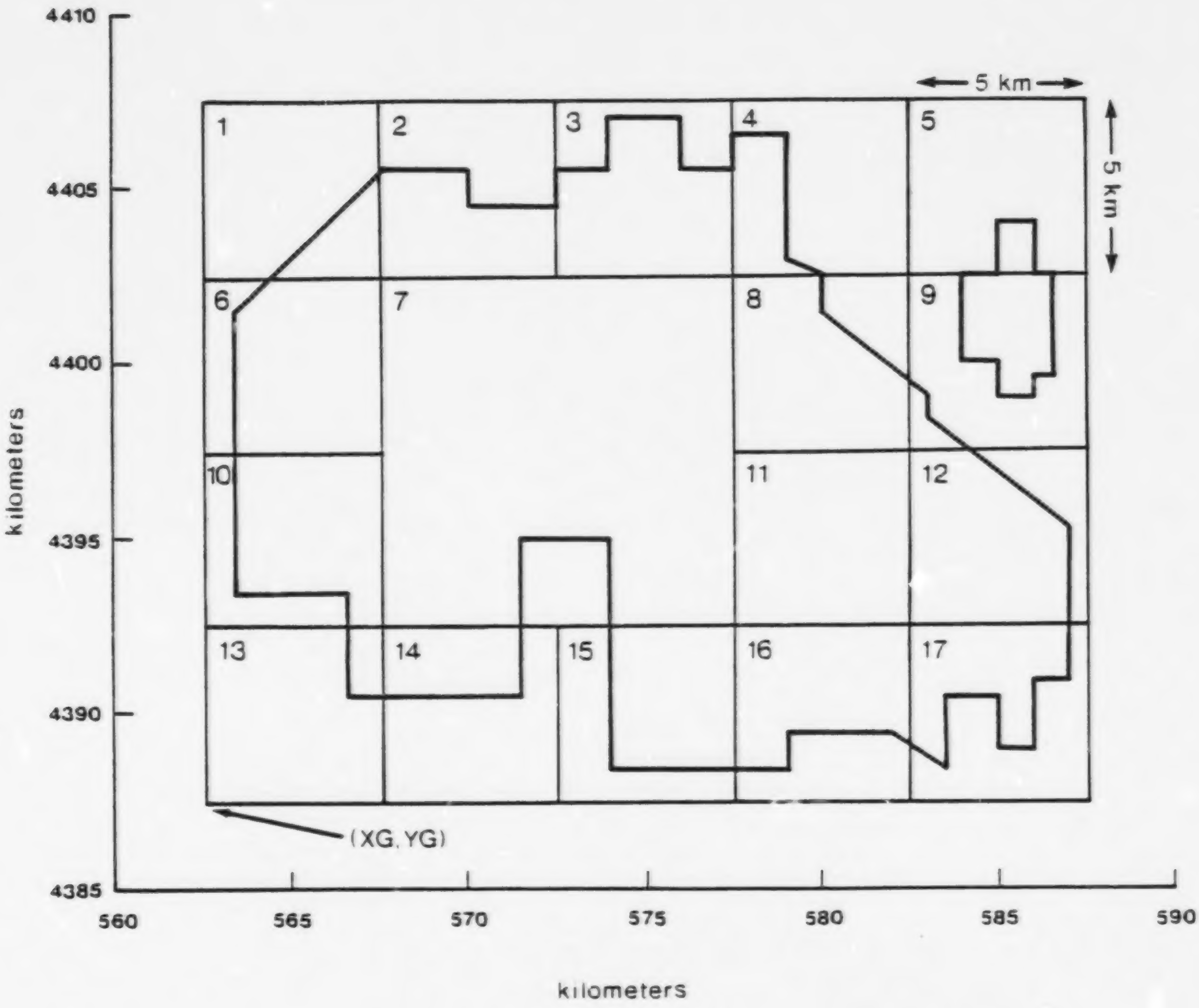
```
                                                                                    Record
Record                                                                                type

AQDM TEST CITY                                                                           1
1    SO2PART                                                                             2
A P1A P2P P1P P2  100    0    5    6    8      0.0      0.0      1.0      1.0           3
16,1,0,0,0,1.,0.,0,0                                                                     4
6,1,1,2,3,4,4                                                                            5
6,1,2,3,4,4,4                                                                            6
  100.    5. 1000. 562.54387.5   15. 5000.                                               7
   10.    1.    1.   30.   30.   30.   30.   30.   30.999999999999                       8
0.1,0.15,0.2,0.25,0.25,0.3                                                               9
1.5,2.45872,4.4704,6.92912,9.61136,12.51712                                             10
1500.,1000.,1000.,1000.,550.,100.                                                       11
(9X,6F9.0)                                                                              12
16 blank card images                                                                    13
          .000500  .000500  .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .0       .000500  .0       .0       .0       .0                               13
          .000500  .0       .0       .0       .0       .0                               13
          .000900  .000500  .000500  .0       .0       .0                               13
          .000900  .0       .0       .0       .0       .0                               13
          .000900  .000500  .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .000900  .0       .0       .0       .0       .0                               13
          .0       .000500  .0       .0       .0       .0                               13
          .000500  .0       .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .0       .0       .0       .0       .0       .0                               13
          .000500  .0       .003200  .0       .0       .0                               13
          .0       .000500  .000900  .0       .0       .0                               13
          .0       .0       .000900  .0       .0       .0                               13
          .000900  .000900  .004600  .0       .0       .0                               13
          .001800  .002800  .004100  .000500  .0       .0                               13
          .0       .003700  .004600  .0       .0       .0                               13
          .001400  .003200  .002800  .0       .0       .0                               13
          .0       .002800  .000900  .0       .0       .0                               13
          .0       .030900  .000900  .0       .0       .0                               13
          .0       .001800  .000900  .0       .0       .0                               13
          .0       .001800  .000900  .0       .0       .0                               13
          .000500  .001400  .000900  .0       .0       .0                               13
          .0       .001400  .000900  .0       .0       .0                               13
          .000500  .000500  .000900  .0       .0       .0                               13
          .0       .000900  .000500  .0       .0       .0                               13
          .0       .001400  .001400  .0       .0       .0                               13
          .0       .001080  .031560  .022980  .002220  .0                               13
          .0       .000540  .008040  .009420  .001680  .0                               13
          .0       .000540  .006360  .008880  .000300  .0                               13
          .0       .002220  .006360  .006360  .000300  .0                               13
          .0       .003360  .008880  .008280  .003300  .000840                          13
          .0       .001680  .006060  .030420  .006660  .000840                          13
          .0       .000840  .013020  .024600  .003060  .000300                          13
          .0       .001080  .010500  .014640  .001680  .0                               13
          .0       .000300  .008880  .018000  .001380  .0                               13
          .0       .000840  .005280  .005280  .0       .0                               13
          .0       .001080  .001080  .0       .0       .0                               13
          .0       .000540  .005280  .000300  .0       .0                               13
          .0       .002460  .007740  .004140  .0       .0                               13
          .0       .002220  .009420  .006660  .001080  .0                               13
          .0       .001380  .014640  .009660  .001680  .0                               13
          .0       .001680  .018000  .019620  .001380  .0                               13
          .0       .000720  .021040  .015320  .001480  .0                               13
          .0       .000360  .005360  .006280  .001120  .0                               13
```

(continued)

TABLE 19. (continued)

```
                                                                            Record
Record                                                                       type
          .0       .000360  .004240  .005920  .000200  .0                   13
          .0       .001480  .004240  .004240  .000200  .0                   13
          .0       .002240  .005920  .005520  .002200  .000560              13
          .0       .001120  .004040  .020280  .004440  .000560              13
          .0       .000560  .008680  .016400  .002040  .000200              13
          .0       .000720  .007000  .009760  .001120  .0                   13
          .0       .000200  .005920  .012000  .000920  .0                   13
          .0       .000560  .003520  .003520  .0       .0                   13
          .0       .000720  .000720  .0       .0       .0                   13
          .0       .000360  .003520  .000200  .0       .0                   13
          .0       .001640  .005160  .002760  .0       .0                   13
          .0       .001480  .006280  .004440  .000720  .0                   13
          .0       .000920  .009760  .006440  .001120  .0                   13
          .0       .001120  .012000  .013080  .000920  .0                   13
          .005100  .012400  .021200  .0       .0       .0                   13
          .000500  .002800  .004600  .0       .0       .0                   13
          .000900  .005100  .002300  .0       .0       .0                   13
          .003200  .007800  .004100  .0       .0       .0                   13
          .010600  .016100  .005500  .0       .0       .0                   13
          .005500  .016100  .012400  .0       .0       .0                   13
          .001400  .006900  .004600  .0       .0       .0                   13
          .000900  .005100  .005100  .0       .0       .0                   13
          .002800  .004600  .002300  .0       .0       .0                   13
          .005100  .006500  .0       .0       .0       .0                   13
          .000900  .003700  .0       .0       .0       .0                   13
          .001800  .003700  .0       .0       .0       .0                   13
          .001800  .006500  .000500  .0       .0       .0                   13
          .005500  .012000  .003700  .0       .0       .0                   13
          .008800  .011100  .003700  .0       .0       .0                   13
          .003200  .011500  .006900  .0       .0       .0                   13
(F6.0,2F7.0,2F8.0,F7.0,F5.0,2F7.0,F5.0)                                     14
 568.5 4403.4          1365.00  527.63   150.                 .0001         15
 584.2 4391.6          1580.36  789.6     90.  8.7   15.2   149.            15
 577.0 4401.1           221.76   34.13    30.   .7   17.8   515.            15
 574.1 4401.5           110.25   54.08    23.  1.4   15.2   260.            15
 562.5 4402.5  5000.      1.37    1.68                                      15
 567.5 4402.5  5000.      1.26    1.79                                      15
 572.5 4402.5  5000.      5.25    3.99    10.                               15
 577.5 4402.5  5000.      1.47   13.13                                      15
 582.5 4402.5  5000.      1.2     1.58                                      15
 562.5 4397.5  5000.      2.62    1.47    10.    To reduce length           15
 567.5 4392.5 10000.     32.66   21.11    15.                               15
 577.5 4397.5  5000.      5.46    3.99    10.    of output listing,         15
 582.5 4397.5  5000.      6.62    5.78    10.    receptors should be        15
 562.5 4392.5  5000.      2.63    1.16    10.    combined into two          15
 577.5 4392.5  5000.      7.88    5.15    20.                               15
 582.5 4392.5  3000.      5.25    3.68    10.    groups - those in          15
 562.5 4387.5  5000.      2.73    1.37           which NROSE ≤ 0            15
 567.5 4387.5  5000.      2.42    1.89    10.    and those in               15
 572.5 4387.5  5000.      5.36    4.10    10.                               15
 577.5 4387.5  5000.      5.57    3.89    10.    which NROSE > 0.           15
 582.5 4387.5  5000.      2.84    1.47    10.                               15
1 blank card image to indicate end of source records                        16
(2F8.2,14X,I4,3X,I4,I5)                                                     17
  570.0  4393.2                  12     8                                   18
  573.9  4388.9                  14    11     ⎫   NROSE ≤ 0                 18
  572.4  4402.2                  50    25     ⎬                             18
  579.0  4394.0                  20     8     ⎭                             18
  583.0  4399.2                  16     7                                   18
  562.0  4395.7                  10     6    1⎫                             18
  566.1  4400.0                  18    10    1⎬   NROSE > 0                 18
  572.5  4396.7                         9    1⎭                             18
  577.5  4397.5                              1                              18
  576.0  4403.0                              1                              18
```



4410
4405
4400
4395
4390
4385
560
565
570
575
580
585
590
kilometers
kilometers
5 km
5 km
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
(XG,YG)

Figure 15. Annotated Test City map (modified from Brubaker et al., 1977).

```
                         CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                  CODE VERSION 85267                        SET-UP INFORMATION
                                       RUN   100

AQDM TEST CITY  ←— Run title

TECHNICAL OPTIONS:

    NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINT
      FREQUENCY FUNCTION (N1636) ...............................   16
    DISPERSION PARAMETER SCHEME FOR AREA SOURCES (KLOW) .......    6          PGCDM, BUSSE & ZIMMERMAN (1973)
    DISPERSION PARAMETER SCHEME FOR POINT SOURCES (KHIGH) .....    6          PGCDM, BUSSE & ZIMMERMAN (1973)
    EFFLUENT RISE FOR AREA SOURCES (FAC) ......................   1.000000E+00
    HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) .............   0.000000E+00 M
    CALIBRATION CONSTANTS --  SO2
        INTERCEPT OF CALIBRATION ..............................   0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ..................................   1.000000E+00 DIMENSIONLESS
    CALIBRATION CONSTANTS -- PART
        INTERCEPT OF CALIBRATION ..............................   0.000000E+00 MICROGRAMS/CU. METER
        SLOPE OF CALIBRATION ..................................   1.000000E+00 DIMENSIONLESS
        INITIAL DISPERSION OPTION (NP50) ......................   1 ⎫ Status of initial dispersion,
        BUOYANCY INDUCED DISPERSION OPTION (NPDH) .............   0 ⎪ buoyancy-induced dispersion,
        STACK DOWNWASH OPTION (NSTDW) .........................   0 ⎬ and stack downwash options.
        GRADUAL PLUME RISE OPTION (NGRAD) .....................   0 ⎪
        DEFAULT OPTION (NDEF) .................................   0 ⎭

PRINT OPTIONS:
                                                       NLIST
    CONTROL FOR PRINTED OUTPUT ................................ →0        Since NLIST = 0, set-up information
    FORTRAN LOGICAL UNIT NUMBER (READ) ........................   5       is echoed for verification.  When
    FORTRAN LOGICAL UNIT NUMBER (PRINTER) .....................   6       NLIST < 0, this page and following
    FORTRAN LOGICAL UNIT NUMBER (PUNCH) .......................   6       page are not printed.

OPERATING PARAMETERS:

    X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (XG) ........   5.625000E+02 USER UNITS
    Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID (YG) ........   4.387500E+03 USER UNITS
    WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ...............   5.000000E+00 USER UNITS
    GRID CONVERSION FACTOR (CV) ...............................   1.000000E+03 M/USER UNITS
    WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ...............   5.000000E+03 M
    NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECTOR (DINT) ....   1.000000E+01 DIMENSIONLESS
    ANGULAR WIDTH OF A SUBSECTOR (THETA) ......................   2.250000E+00 DEG
    INITIAL RADIAL INCREMENT (DELR) ...........................   1.000000E+02 M

MISCELLANEOUS METEOROLOGICAL DATA:

    AMBIENT AIR TEMPERATURE (TOA) .............................   2.881600E+02 K
    MIXING HEIGHTS BY STABILITY CLASS (HL):
       STABILITY CLASS:      1 ................................   1.500000E+03 M
                             2 ................................   1.000000E+03 M
                             3 ................................   1.000000E+03 M
                             4 ................................   1.000000E+03 M
                             5 ................................   5.500000E+02 M
                             6 ................................   1.000000E+02 M
```

Figure 16. Printed output for the example problem.

SET-UP INFORMATION (continued)

```
                    CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                CODE VERSION 85267
                                     RUN   100

AQDM TEST CITY ←——Run title included on every page of listing

MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):

  CENTRAL WIND SPEED OF THE SIX WIND SPEED CLASSES (U):
    WIND SPEED CLASS:   1 ................................    1.500000E+00 M/SEC
                        2 ................................    2.458720E+00 M/SEC
                        3 ................................    4.470400E+00 M/SEC
                        4 ................................    6.929120E+00 M/SEC
                        5 ................................    9.611360E+00 M/SEC
                        6 ................................    1.251712E+01 M/SEC

  EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):
    STABILITY CLASS:    1 ................................    1.000000E-01 DIMENSIONLESS
                        2 ................................    1.500000E-01 DIMENSIONLESS
                        3 ................................    2.000000E-01 DIMENSIONLESS
                        4 ................................    2.500000E-01 DIMENSIONLESS
                        5 ................................    2.500000E-01 DIMENSIONLESS
                        6 ................................    3.000000E-01 DIMENSIONLESS


SOURCE DATA:

  POLLUTANTS TO BE MODELED ...............................     SO2 & PART
  DECAY HALF-LIFE FOR SO2 (GB(1)) ........................    9.999990E+05 HR
  DECAY HALF-LIFE FOR PART (GB(2)) .......................    9.999990E+05 HR
  DAYTIME EMISSION WEIGHT FACTOR (YD) ....................    1.000000E+00 DIMENSIONLESS
  NIGHTTIME EMISSION WEIGHT FACTOR (YN) ..................    1.000000E+00 DIMENSIONLESS
  INITIAL SIGMA-Z FOR AREA SOURCES (SZA):
    STABILITY CLASS:    1 ................................    3.000000E+01 M
                        2 ................................    3.000000E+01 M
                        3 ................................    3.000000E+01 M
                        4 ................................    3.000000E+01 M
                        5 ................................    3.000000E+01 M
                        6 ................................    3.000000E+01 M

DISPERSION CURVE USED FOR EACH STABILTY CLASS
   STABILITY        POINT          AREA
     CLASS         SOURCES        SOURCES
       1              A              A
       2              B              A
       3              C              B
       4              D1             C
       5              D1             D1
       6              D1             D1
```

Figure 16. (continued).

METEOROLOGY

When NLIST < 0, the meteorological joint frequency function is not printed.

Output is abridged. The meteorological joint frequency function is missing for stability classes 2, 3, 4, and 5.

```
                    CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                CODE VERSION 85267
                                   RUN   100

AQDM TEST CITY

                    METEOROLOGICAL JOINT FREQUENCY FUNCTION

STABILITY CLASS 1                                  WIND SPEED CLASS

   WIND DIRECTION    SECTOR        1          2          3          4          5          6

        N              1       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNE            2       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NE             3       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ENE            4       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        E              5       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        ESE            6       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SE             7       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSE            8       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        S              9       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SSW           10       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        SW            11       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WSW           12       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        W             13       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        WNW           14       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NW            15       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000
        NNW           16       0.000000   0.000000   0.000000   0.000000   0.000000   0.000000

                                             COMPUTED MEAN SPEED =   0.00 M/SEC


STABILITY CLASS 6                                  WIND SPEED CLASS

   WIND DIRECTION    SECTOR        1          2          3          4          5          6

        N              1       0.005100   0.012400   0.021200   0.000000   0.000000   0.000000
        NNE            2       0.000500   0.002800   0.004600   0.000000   0.000000   0.000000
        NE             3       0.000900   0.005100   0.002800   0.000000   0.000000   0.000000
        ENE            4       0.003200   0.007800   0.004100   0.000000   0.000000   0.000000
        E              5       0.010600   0.016100   0.005500   0.000000   0.000000   0.000000
        ESE            6       0.005500   0.016100   0.012400   0.000000   0.000000   0.000000
        SE             7       0.001400   0.006900   0.004600   0.000000   0.000000   0.000000
        SSE            8       0.000900   0.005100   0.005100   0.000000   0.000000   0.000000
        S              9       0.002800   0.004600   0.002300   0.000000   0.000000   0.000000
        SSW           10       0.005100   0.006500   0.000000   0.000000   0.000000   0.000000
        SW            11       0.000900   0.003700   0.000000   0.000000   0.000000   0.000000
        WSW           12       0.001800   0.003700   0.000000   0.000000   0.000000   0.000000
        W             13       0.001800   0.006500   0.000500   0.000000   0.000000   0.000000
        WNW           14       0.005500   0.012000   0.003700   0.000000   0.000000   0.000000
        NW            15       0.008800   0.011100   0.003700   0.000000   0.000000   0.000000
        NNW           16       0.003200   0.011500   0.006900   0.000000   0.000000   0.000000

                                             COMPUTED MEAN SPEED =   2.83 M/SEC
```

Average wind speed for stability class 6. ——→ COMPUTED MEAN SPEED = 2.83 M/SEC

Figure 16. (continued).

```
                    CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                               CODE VERSION 85287
                                  RUN    100

AQDM TEST CITY

                              AREA AND POINT SOURCE INVENTORY

                                                                                    STACK       STACK          OPTIONAL
                             WIDTH OF     ----EMISSION RATE----     SOURCE   STACK   EXIT        GAS         PLUME RISE
   X MAP        Y MAP      GRID SQUARE       SO2          PART      HEIGHT    DIAM   SPEED       TEMP        COEFFICIENT
COORDINATE   COORDINATE        (M)         (G/SEC)      (G/SEC)      (M)      (M)   (M/SEC)    (DEG C)       (M**2/SEC)

  568.50       4403.40          0.          1335.00      527.63     150.00    0.00    0.00        0.0           0.00
  584.20       4391.60          0.          1580.36      789.60      90.00    8.70   15.20      140.0           0.00
  577.00       4401.10          0.           321.76       34.13      30.00    0.70   17.80      515.0           0.00
  574.10       4401.50          0.           110.25       54.08      23.00    1.40   15.20      260.0           0.00
  562.50       4402.50       5000.             1.37        1.68       0.00    0.00    0.00        0.0           0.00
  567.50       4402.50       5000.             1.26        1.79       0.00    0.00    0.00        0.0           0.00
  572.50       4402.50       5000.             5.25        3.98      10.00    0.00    0.00        0.0           0.00
  577.50       4402.50       5000.             1.47       13.13       0.00    0.00    0.00        0.0           0.00
  582.50       4402.50       5000.             1.20        1.58       0.00    0.00    0.00        0.0           0.30
  562.50       4397.50       5000.             2.62        1.47      10.00    0.00    0.00        0.0           0.00
  567.50       4392.50      10000.            32.66       21.11      15.00    0.00    0.00        0.0           0.00
  577.50       4397.50       5000.             5.46        3.99      10.00    0.00    0.00        0.0           0.00
  582.50       4397.50       5000.             6.62        5.78      10.00    0.00    0.00        0.0           0.00
  562.50       4392.50       5000.             2.63        1.16      10.00    0.00    0.00        0.0           0.00
  577.50       4392.50       5000.             7.88        5.15      20.00    0.00    0.00        0.0           0.00
  582.50       4392.50       5000.             5.25        3.68      10.00    0.00    0.00        0.0           0.00
  562.50       4387.50       5000.             2.73        1.37       0.00    0.00    0.00        0.0           0.00
  567.50       4387.50       5000.             2.42        1.89      10.00    0.00    0.00        0.0           0.00
  572.50       4387.50       5000.             5.36        4.10      10.00    0.00    0.00        0.0           0.00
  577.50       4387.50       5000.             5.57        3.89      10.00    0.00    0.00        0.0           0.00
  582.50       4387.50       5000.             2.84        1.47      10.00    0.00    0.00        0.0           0.00

          17 AREA SOURCES.          4 POINT SOURCES.
```

Total number of area and point sources

Since NLIST = 0, the source inventory is echoed for verification. When NLIST ≠ 0, this information is not printed.

Figure 16. (continued).

CONCENTRATION RESULTS

Receptors in which
NROSE = 0.

```
                       CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                   CODE VERSION 85267
                                      RUN   100

AQDM TEST CITY

                             CONCENTRATIONS (MICROGRAMS/CU. METER)

                         AREA  SOURCES       POINT  SOURCES      -----TOTAL-----     --CALIBRATED--     ---OBSERVED---
X COORD    Y COORD        SO2     PART         SO2     PART        SO2      PART        SO2     PART       SO2      PART

 570.00    4393.20        5.4      3.8        14.8      5.5       20.3       9.3       20.3      9.3        12         8
 573.90    4388.90        4.6      3.4         9.5      3.6       14.1       7.0       14.1      7.0        14        11
 572.40    4402.20        4.9      4.3        39.5     13.0       44.4      17.3       44.4     17.3        50        26
 579.00    4394.00        5.4      4.3        15.3      4.4       20.7       8.7       20.7      8.7        20         8
 583.00    4399.20        4.5      4.9        11.3      3.0       15.8       7.9       15.8      7.9        16         7
```

CDM-2.0 provides separate point and area source contributions.

"Total" and "calibrated" concentrations are identical since slope and intercept input as 1 and 0, respectively.

Note *In order to reduce length of output listing, receptors should be combined into two groups on input: those in which NROSE ≤ 0 and those in which NROSE > 0.*

Figure 16. (continued).

CONCENTRATION RESULTS (continued)

```
                                      CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                                  CODE VERSION 85267
                                                     RUN    100
AQDM TEST CITY

                                            CONCENTRATIONS (MICROGRAMS/CU. METER)

                            AREA  SOURCES       POINT  SOURCES       -----TOTAL-----       --CALIBRATED--       ---OBSERVED---
X COORD     Y COORD          SO2     PART         SO2     PART         SO2      PART         SO2      PART         SO2      PART
 562.00     4395.70          2.7      1.9         6.2      2.2         8.9       4.0         8.9       4.0         10          6

**************************************** AVERAGE CONCENTRATIONS BY STABILITY ****************************************

                                   TYPE OF   -------------STABILITY CATEGORY--------------
                        POLLUTANT  SOURCE       1        2        3        4        5        6
                         1 ( SO2)   AREA       0.0      0.0      0.1      0.2      0.4      2.0
                         1 ( SO2)   POINT      0.0      0.1      0.4      2.7      1.8      1.2

                         2 (PART)   AREA       0.0      0.0      0.0      0.1      0.3      1.4
                         2 (PART)   POINT      0.0      0.0      0.2      1.0      0.7      0.2

**************************************** AREA ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
       1          0     0     0     0     1     1     0     0     0     0     0     0     0     0     0     0
       2          0     0     0     0     1     0     0     0     0     0     0     0     0     0     0     0

**************************************** POINT ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
       1          0     0     3     2     1     0     0     0     0     0     0     0     0     0     0     0
       2          0     0     1     1     1     0     0     0     0     0     0     0     0     0     0     0
********************************************************************************************************************
```

NROSE > 0 for this receptor, thus concentration versus stability histogram and concentration roses provided.

Figure 16. (continued).

```
                              CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                           CODE VERSION 85267
                                           RUN    100                     CONCENTRATION RESULTS (continued)
AQDM TEST CITY

                                     CONCENTRATIONS (MICROGRAMS/CU. METER)

                       AREA  SOURCES      POINT  SOURCES     -----TOTAL-----     --CALIBRATED--      ---OBSERVED---
X COORD    Y COORD      SO2     PART        SO2     PART       SO2      PART       SO2     PART        SO2      PART
 566.10    4400.00      4.2      3.1       12.5      4.1      16.7       7.3      16.7      7.3         18        10

*************************************** AVERAGE CONCENTRATIONS BY STABILITY *****************************************

                               TYPE OF   -------------STABILITY CATEGORY--------------
                   POLLUTANT   SOURCE        1       2       3       4       5       6
                    1 ( SO2)    AREA       0.0     0.0     0.1     0.5     0.8     2.7
                    1 ( SO2)    POINT      0.0     0.2     1.0     4.8     3.2     3.2

                    2 (PART)    AREA       0.0     0.0     0.1     0.3     0.6     2.1
                    2 (PART)    POINT      0.0     0.1     0.4     1.8     1.2     0.6

*************************************** AREA ROSES (MICROGRAMS/CU. METER) *****************************************

    POLLUTANT      N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
        1          0    0     0    0     1    1     0    0     0    0     0    0     0    0     0    0
        2          0    0     0    1     1    1     0    0     0    0     0    0     0    0     0    0

*************************************** POINT ROSES (MICROGRAMS/CU. METER) *****************************************

    POLLUTANT      N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
        1          0    0     4    0     7    2     0    0     0    0     0    0     0    0     0    0
        2          0    0     2    0     2    1     0    0     0    0     0    0     0    0     0    0
******************************************************************************************************************
```

Figure 16. (continued).

```
                        CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                  CODE VERSION 85267
                                      RUN   100                    CONCENTRATION RESULTS (continued)

AQDM TEST CITY

                                  CONCENTRATIONS (MICROGRAMS/CU. METER)

                        AREA  SOURCES      POINT  SOURCES     -----TOTAL-----     --CALIBRATED--     ---OBSERVED---
X COORD   Y COORD        SO2     PART        SO2     PART        SO2      PART       SO2     PART        SO2     PART
 572.50   4396.70        6.0      4.3       17.5      6.3       23.5      10.6      23.5     10.6          0        9

**************************************** AVERAGE CONCENTRATIONS BY STABILITY ****************************************

                          TYPE OF   ---------------STABILITY CATEGORY---------------
              POLLUTANT   SOURCE       1        2        3        4        5        6
               1 ( SO2)    AREA       0.0      0.0      0.2      0.9      1.3      3.6
               1 ( SO2)    POINT      0.0      0.0      0.9      8.6      5.7      2.2

               2 (PART)    AREA       0.0      0.0      0.1      0.6      0.9      2.6
               2 (PART)    POINT      0.0      0.0      0.4      3.2      2.2      0.5

**************************************** AREA ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT     N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
       1         1    0    0    0      1    1    0    0      0    0    0    0      0    0    1    0
       2         0    0    0    0      1    1    0    0      0    0    0    0      0    0    0    0

**************************************** POINT ROSES (MICROGRAMS/CU. METER) ****************************************

   POLLUTANT     N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
       1         0    2    4    0      0    2    0    0      0    0    0    0      0    0    0    9
       2         0    1    1    0      0    1    0    0      0    0    0    0      0    0    0    4

*******************************************************************************************************************
```

Figure 16. (continued).

CONCENTRATION RESULTS (continued)

```
                                        CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                                  CODE VERSION 85267
                                                       RUN   100

AQDM TEST CITY

                                         CONCENTRATIONS (MICROGRAMS/CU. METER)

                         AREA   SOURCES       POINT  SOURCES       -----TOTAL-----       --CALIBRATED--       ---OBSERVED---
X COORD    Y COORD        SO2      PART         SO2     PART         SO2      PART         SO2     PART         SO2      PART

 577.50    4397.50        5.5       4.4        34.2      7.6        39.8      12.0        39.8     12.0           0         0

***************************************** AVERAGE CONCENTRATIONS BY STABILITY *****************************************

                                      TYPE OF   --------------STABILITY CATEGORY---------------
                          POLLUTANT   SOURCE       1        2        3        4        5        6
                           1 ( SO2)    AREA       0.0      0.0      0.1      0.8      1.2      3.3
                           1 ( SO2)    POINT      0.0      0.3      1.1     14.7      9.8      8.3

                           2 (PART)    AREA       0.0      0.0      0.1      0.6      1.0      2.7
                           2 (PART)    POINT      0.0      0.1      0.4      3.5      2.3      1.4

****************************************** AREA ROSES (MICROGRAMS/CU. METER) ******************************************

      POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
          1          1     0     0     0     1     1     0     0     0     0     0     0     0     1     1     0
          2          1     0     0     0     0     0     0     0     0     0     0     0     0     0     0     0

***************************************** POINT ROSES (MICROGRAMS/CU. METER) ******************************************

      POLLUTANT      N   NNE    NE   ENE     E   ESE    SE   SSE     S   SSW    SW   WSW     W   WNW    NW   NNW
          1         26     0     0     0     0     0     2     0     0     0     0     0     0     4     3     0
          2          4     0     0     0     0     0     1     0     0     0     0     0     0     2     1     0

************************************************************************************************************************
```

Figure 16. (continued).

```
                         CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0
                                   CODE VERSION 85267
                                       RUN   100                         CONCENTRATION RESULTS (continued)

  AQDM TEST CITY

                                 CONCENTRATIONS (MICROGRAMS/CU. METER)

                              AREA  SOURCES     POINT  SOURCES      -----TOTAL-----      --CALIBRATED--      ---OBSERVED---
 X COORD    Y COORD            SO2     PART       SO2     PART        SO2      PART        SO2     PART        SO2      PART
  576.00    4403.00            4.4      4.8      27.8      6.2       32.3      11.0       32.3     11.0          0         0

****************************** AVERAGE CONCENTRATIONS BY STABILITY ******************************

                         TYPE OF    -------------STABILITY CATEGORY-------------
              POLLUTANT  SOURCE       1       2       3       4       5       6
              1 ( SO2)    AREA       0.0     0.0     0.1     0.7     1.0     2.6
              1 ( SO2)    POINT      0.0     0.1     2.4    12.6     8.4     4.3

              2 (PART)    AREA       0.0     0.0     0.1     0.7     1.0     3.0
              2 (PART)    POINT      0.0     0.0     0.7     2.9     1.9     0.7

****************************** AREA ROSES (MICROGRAMS/CU. METER) ******************************

    POLLUTANT      N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
        1          0    0     0    0     0    1     0    0     0    0     0    0     0    0     0    0
        2          0    0     0    1     1    1     0    0     0    0     0    0     0    0     0    0

****************************** POINT ROSES (MICROGRAMS/CU. METER) ******************************

    POLLUTANT      N   NNE   NE   ENE    E   ESE   SE   SSE    S   SSW   SW   WSW    W   WNW   NW   NNW
        1          0    0     0    0     0    0     2   21     0    0     1    0     4    0     0    0
        2          0    0     0    0     0    0     1    3     0    0     0    0     2    0     0    0

**************************************************************************************************
```

Figure 16. (continued).

TABLE 20. CARD IMAGE OUTPUT FOR THE EXAMPLE PROBLEM.

```
                                                                           Record
Card image output                                                            type
     570.00   4393.20  100I   5   4  15   5  20    9  20    9  12    8          1
     573.90   4388.90  100I   5   3  10   4  14    7  14    7  14   11          1
     572.40   4402.20  100I   5   4  39  13  44   17  44   17  50   26          1
     579.00   4394.00  100I   5   4  15   4  21    9  21    9  20    8          1
     583.00   4399.20  100I   5   5  11   3  16    8  16    8  16    7          1
     562.00   4395.70  100I   3   2   6   2   9    4   9    4  10    6          1
A P1     0.0      0.0   0.1   0.2     0.4     2.0   56200   439570              2
P P1     0.0      0.1   0.4   2.7     1.8     1.2   56200   439570              3
A P2     0.0      0.0   0.0   0.1     0.3     1.4   56200   439570              4
P P2     0.0      0.0   0.2   1.0     0.7     0.2   56200   439570              5
A P1     0     0    0     0   1   1   0   0    56200  439570                    6
A P1     0     0    0     0   0   0   0   0    56200  439570                    6
A P2     0     0    0     0   1   0   0   0    56200  439570                    7
A P2     0     0    0     0   0   0   0   0    56200  439570                    7
P P1     0     0    3     2   1   0   0   0    56200  439570                    8
P P1     0     0    0     0   0   0   0   0    56200  439570                    8
P P2     0     0    1     1   1   0   0   0    56200  439570                    9
P P2     0     0    0     0   0   0   0   0    56200  439570                    9
   .                .                     .
   .                .                     .
   .                .                     .
     576.00   4403.00  100I   4   5  28   6  32   11  32   11   0    0          1
A P1     0.0      0.0   0.1   0.7     1.0     2.6   57600   440300              2
P P1     0.0      0.1   2.4  12.6     8.4     4.3   57600   440300              3
A P2     0.0      0.0   0.1   0.7     1.0     3.0   57600   440300              4
P P2     0.0      0.0   0.7   2.9     1.9     0.7   57600   440300              5
A P1     0     0    0     0   0   1   0   0    57600  440300                    6
A P1     0     0    0     0   0   0   0   0    57600  440300                    6
A P2     0     0    0     1   1   1   0   0    57600  440300                    7
A P2     0     0    0     0   0   0   0   0    57600  440300                    7
P P1     0     0    0     0   0   0   2  21    57600  440300                    8
P P1     0     0    1     0   4   0   0   0    57600  440300                    8
P P2     0     0    0     0   0   0   1   3    57600  440300                    9
P P2     0     0    0     0   2   0   0   0    57600  440300                    9
```

TABLE 21. FORMAT OF CARD IMAGE OUTPUT.

Record type, Variable	Column	Format	Variable description (units)
Record type 1			
RX	1-10	F10.2	X map coordinate of receptor (user units)
RY	11-20	F10.2	Y map coordinate of receptor (user units)
IRUN	21-25	I5	Run identification number
--	26	--	Card identifier
KPX(1)	27-30	I4	Concentration contribution from area sources for the first pollutant ($\mu g/m^3$)
KPX(2)	31-34	I4	Concentration contribution from area sources for the second pollutant ($\mu g/m^3$)
KPX(3)	35-38	I4	Concentration contribution from point sources for the first pollutant ($\mu g/m^3$)
KPX(4)	39-42	I4	Concentration contribution from point sources for the second pollutant ($\mu g/m^3$)
KPX(5)	43-45	I4	Total concentration for the first pollutant ($\mu g/m^3$)
KPX(6)	46-50	I4	Total concentration for the second pollutant ($\mu g/m^3$)
KPX(7)	51-54	I4	Calibrated total concentration for the first pollutant ($\mu g/m^3$)
KPX(8)	55-58	I4	Calibrated total concentration for the second pollutant ($\mu g/m^3$)
KPX(9)	59-62	I4	Observed concentration for the first pollutant ($\mu g/m^3$)
KPX(10)	63-66	I4	Observed concentration for the second pollutant ($\mu g/m^3$)

(continued)

TABLE 21 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 2*			
AROS	1- 4	A4	Identifier indicating area source contribution for the first pollutant
APAR	5-46	6F7.1	Area source contribution by stability class for the first pollutant (μg/m^3)
KPX(37)	47-54	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
KPX(38)	55-62	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 3*			
PROS	1- 4	A4	Identifier indicating point source contribution for the first pollutant
PPAR	5-46	6F7.1	Point source contribution by stability class for the first pollutant (μg/m^3)
KPX(37)	47-54	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
KPX(38)	55-62	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 4*			
--	---	--	Same as record type 2 for the second pollutant
Record type 5*			
--	---	--	Same as record type 3 for the second pollutant

(continued)

TABLE 21 (continued)

Record type, Variable	Column	Format	Variable description (units)
Record type 6*†			
AROS	1- 4	A4	Identifier indicating area source contribution for the first pollutant
KPX	5-44	8I5	Area source contribution by wind direction starting at north and rotating clockwise (μg/m^3)
RX	45-52	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
RY	53-60	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 7*†			
--	---	--	Same as record type 6 for the second pollutant
Record type 8*†			
PROS	1- 4	A4	Identifier indicating point source contribution for the first pollutant
KPX	5-44	8I5	Point source contribution by wind direction starting at north and rotating clockwise (μg/m^3)
RX	45-52	I8	X map coordinate of receptor multiplied by 100 to remove decimals (user units)
RY	53-60	I8	Y map coordinate of receptor multiplied by 100 to remove decimals (user units)
Record type 9*†			
--	---	--	Same as record type 8 for the second pollutant

* Records written only if NROSE > 0.

† If N1636 = 16 there are two records of this type; if N1636 = 36 there are four records of this type.

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APPENDIX A

DEFAULT OPTION

The default option is provided as a convenience to the user to help avoid inadvertent errors in setting the appropriate options. Exercising the default option (i.e., NDEF = 1) overrides other user-input selections and results in the following.

(1) Stack downwash according to Briggs (1974) is used.

(2) Briggs' plume rise (1969, 1971, and 1975) is used.

(3) Buoyancy-induced dispersion is exercised. For distances less than the distance to final rise, the gradual plume rise is used to determine the buoyancy-induced dispersion only.

(4) Final plume rise is used.

(5) To calculate vertical dispersion, the Briggs-urban scheme is selected.

(6) The joint frequency function is assumed to be comprised of the following six classes: A, B, C, D-day, D-night, and nighttime stable.

(7) Initial σ_z values for area sources are 30 meters for all stability classes.

(8) Wind profile exponents are set to .15, .15, .20, .25, .25, and .30 for stabilities A, B, C, D-day, D-night, and stable cases respectively.

(9) Calibration intercepts and slopes are set to 0 and 1, respectively.

(10) A pollutant half-life of 4 hours for SO_2 is assumed and a half-life near infinity is assumed for all other pollutants.

Default values for all the affected variables are provided in Table A-1. For all other input variables not shown in Table A-1, CDM-2.0 assumes the values provided by the user.

TABLE A-1. VARIABLES AFFECTED BY THE DEFAULT OPTION

Record type	Variable	Default values
3	CA	0.0, 0.0
	CB	1.0, 1.0
4	NP50	-1
	NPDH	1
	NSTDW	1
5	KLOW	2
	ICA	1, 2, 3, 4, 5, 6
6	KHIGH	2
	ICP	1, 2, 3, 4, 5, 6
8	SZA	30., 30., 30., 30., 30., 30.
	GB	4.0 (for SO_2), 999999. (for all others)
9	UE	.15, .15, .20, .25, .25, .30
10	SA	-1

APPENDIX B

DETAILED FLOW DIAGRAMS

Detailed flow diagrams for the main program and the four primary subroutines (i.e., CLINT, CALQ, AREA, and POINT) follow.

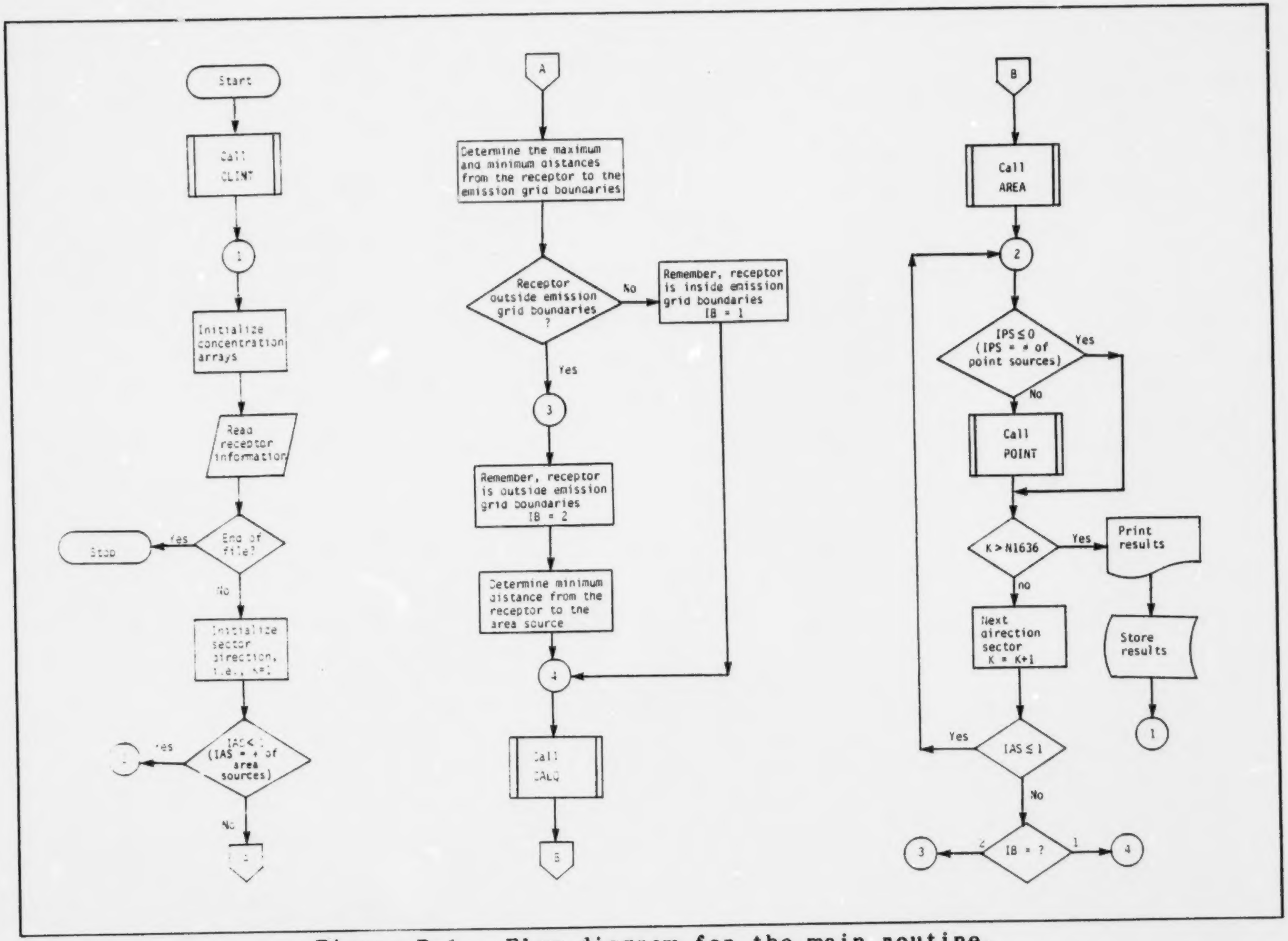
Start
Call CLINT
1
Initialize concentration arrays
Read receptor information
End of file?
Yes
Stop
No
Initialize sector direction, i.e., K=1
IAS<1 (IAS = # of area sources)
Yes
No
A
Determine the maximum and minimum distances from the receptor to the emission grid boundaries
Receptor outside emission grid boundaries ?
No
Remember, receptor is inside emission grid boundaries IB = 1
Yes
3
Remember, receptor is outside emission grid boundaries IB = 2
Determine minimum distance from the receptor to the area source
4
Call CALQ
B
B
Call AREA
2
IPS≤0 (IPS = # of point sources)
Yes
No
Call POINT
K > N1636
Yes
Print results
Store results
1
no
Next direction sector K = K+1
IAS ≤ 1
Yes
No
IB = ?
2
1
3
4

Figure B-1. Flow diagram for the main routine.

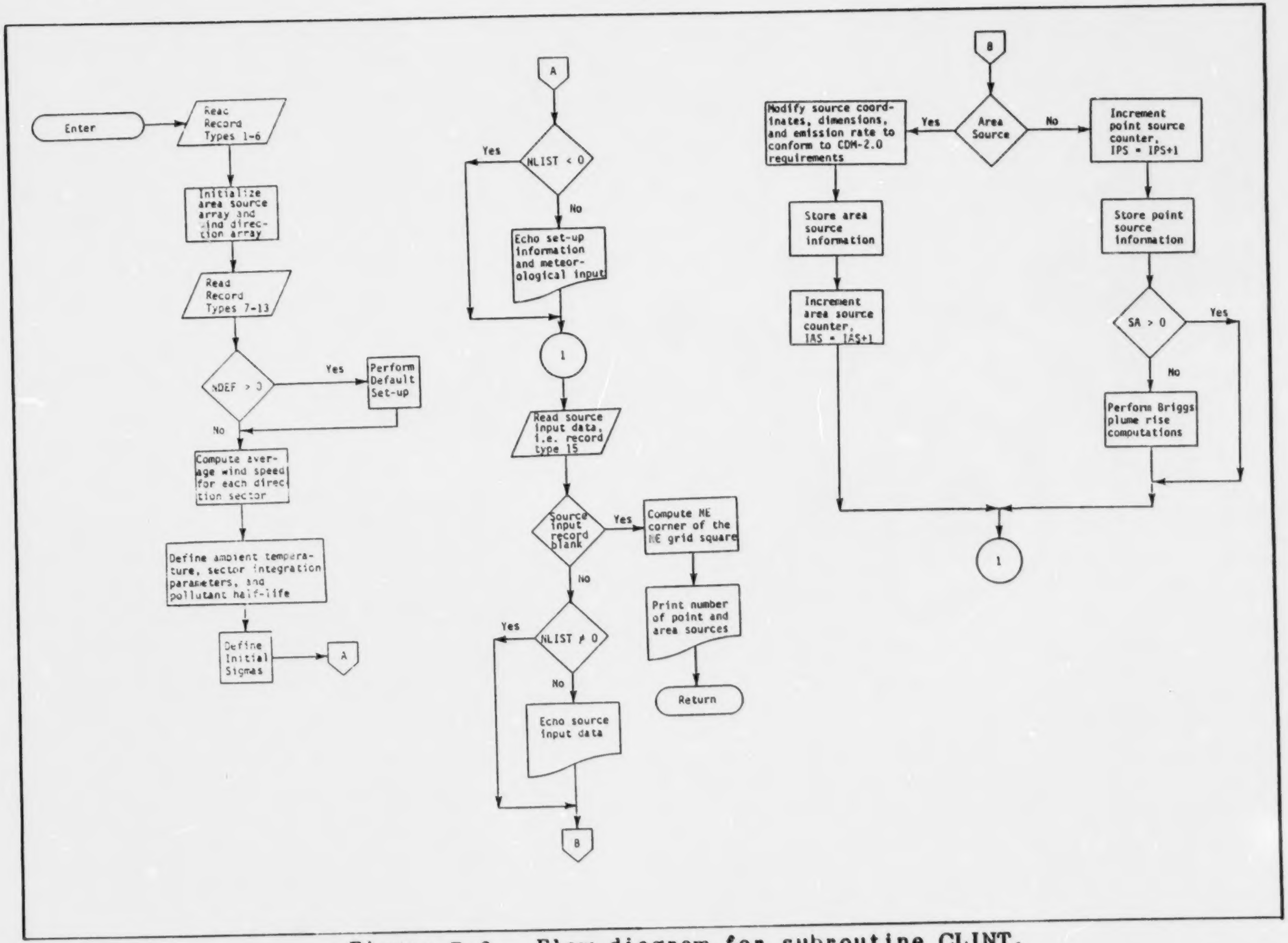
Enter
Reac Record Types 1-6
Initialize area source array and wind direction array
Read Record Types 7-13
NDEF > 0
Yes
Perform Default Set-up
No
Compute average wind speed for each direction sector
Define ambient temperature, sector integration parameters, and pollutant half-life
Define Initial Sigmas
A
A
NLIST < 0
Yes
No
Echo set-up information and meteorological input
1
Read source input data, i.e. record type 15
Source input record blank
Yes
Compute NE corner of the NE grid square
Print number of point and area sources
Return
No
NLIST ≠ 0
Yes
No
Echo source input data
B
B
Area Source
Yes
Modify source coordinates, dimensions, and emission rate to conform to CDM-2.0 requirements
Store area source information
Increment area source counter, IAS = IAS+1
No
Increment point source counter, IPS = IPS+1
Store point source information
SA > 0
Yes
No
Perform Briggs plume rise computations
1

Figure B-2. Flow diagram for subroutine CLINT.

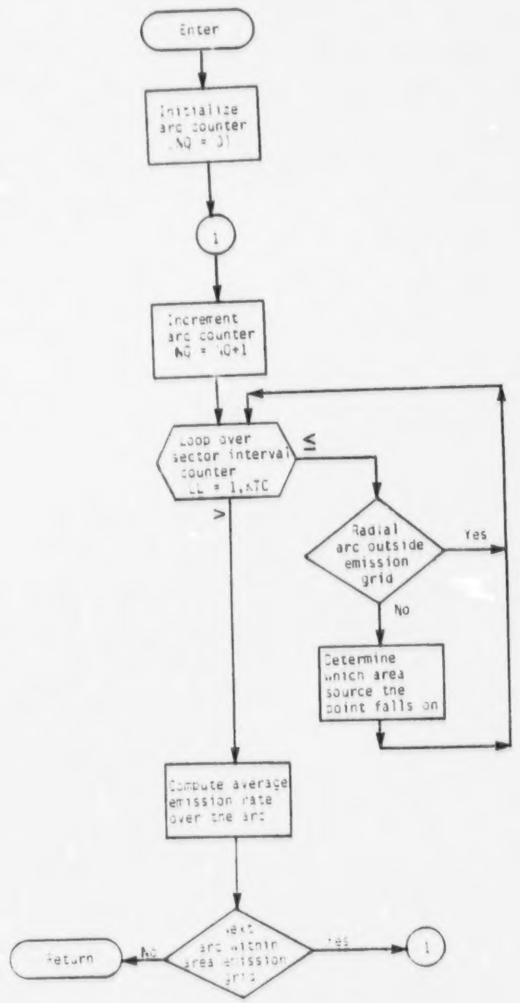
Enter
Initialize arc counter (NQ = 0)
1
Increment arc counter NQ = NQ+1
Loop over sector interval counter LL = 1,KTC
≤
>
Radial arc outside emission grid
Yes
No
Determine which area source the point falls on
Compute average emission rate over the arc
Next arc within area emission grid
Yes
1
No
Return

Figure B-3. Flow diagram for subroutine CALQ.

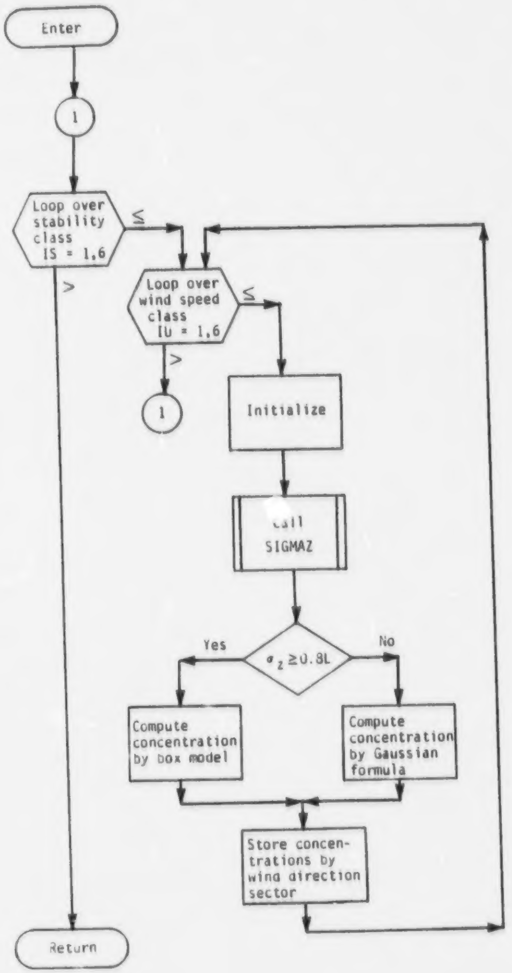
Enter
1
Loop over stability class IS = 1,6
≤
>
Loop over wind speed class IU = 1,6
≤
>
1
Initialize
Call SIGMAZ
$\sigma_z \geq 0.8L$
Yes
No
Compute concentration by box model
Compute concentration by Gaussian formula
Store concentrations by wind direction sector
Return

Figure B-4. Flow diagram for subroutine AREA.

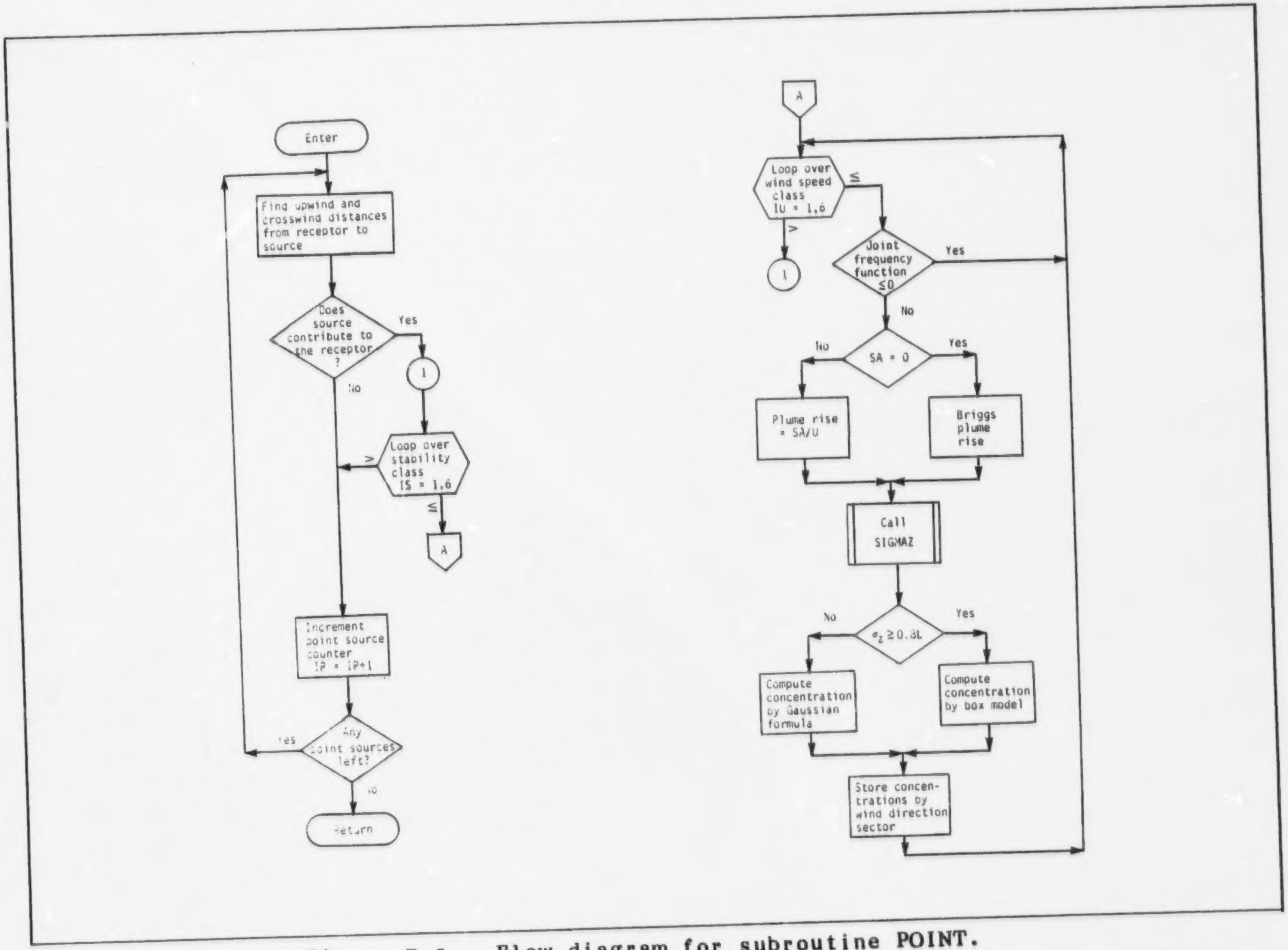
Enter
Find upwind and crosswind distances from receptor to source
Does source contribute to the receptor ?
Yes
No
1
Loop over stability class IS = 1,6
>
≤
A
Increment point source counter IP = IP+1
Any point sources left?
Yes
No
Return
A
Loop over wind speed class IU = 1,6
≤
>
1
Joint frequency function ≤0
Yes
No
SA = 0
No
Yes
Plume rise = SA/U
Briggs plume rise
Call SIGMAZ
σz ≥ 0.3L
No
Yes
Compute concentration by Gaussian formula
Compute concentration by box model
Store concentrations by wind direction sector

Figure B-5. Flow diagram for subroutine POINT.

APPENDIX C

LISTING OF FORTRAN SOURCE CODE

The source code listing of CDM-2.0 follows. The program consists of a main module and nine subroutines.

```
C               CDM-2.0 CLIMATOLOGICAL DISPERSION MODEL VERSION 2.0 (BATCH)
C                       CDM-2.0    (VERSION 85293)
C
C
C
C
C
C
C * * *    PROGRAM ABSTRACT
C
C         CDM-2.0 DETERMINES LONG-TERM (SEASONAL OR ANNUAL) QUASI-
C         STABLE POLLUTANT CONCENTRATIONS IN A RURAL OR URBAN SETTING
C         USING AVERAGE EMISSION RATES FROM POINT AND AREA SOURCES AND
C         A JOINT FREQUENCY DISTRIBUTION OF WIND DIRECTION, WIND SPEED,
C         AND STABILITY.  THE GAUSSIAN PLUME HYPOTHESIS FORMS THE BASIS
C         FOR THE CALCULATIONS.  CONTRIBUTIONS ARE CALCULATED ASSUMING
C         THE NARROW PLUME HYPOTHESIS, CALDER (1971, 1977), AND INVOLVE
C         AN UPWIND INTEGRATION OVER THE AREA SOURCES.  COMPUTATIONS
C         CAN BE MADE FOR UP TO 200 POINT SOURCES AND 2500 AREA SOURCES
C         AT AN UNLIMITED NUMBER OF RECEPTOR LCCATIONS.  THE NUMBER OF
C         POINT AND AREA SOURCES CAN BE EASILY MODIFIED WITHIN THE CODE
C         CDM-2.0 IS AN ENHANCED VERSION OF CDM INCLUDING THE FOLLOWING
C         OPTIONS:  16 OR 36 WIND DIRECTION SECOTRS, INITIAL PLUME
C         DISPERSION, BUOYANCY-INDUCED DISPERSION, STACK DOWNWASH, AND
C         GRADUAL PLUME RISE.  THE USER HAS A CHOICE OF SEVEN DISPERSIO
C         PARAMETER SCHEMES.  OPTIONAL OUTPUT INCLUDES POINT AND AREA
C         CONCENTRATION ROSES AND HISTOGRAMS OF POLLUTANT CONCENTRATION
C         BY STABILITY CLASS.
C
C
C * * *    REFERENCES
C
C         IRWIN, J. S., T. CHICO, AND J. A. CATALANO.  1985.  CDM-2.0 -
C         CLIMATOLOGICAL DISPERSION MODEL VERSION 2.0.  EPA-___/_-_-___
C         U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK
C         NC.  ___ PP.
C
C
C * * *    STRUCTURE AND MODULE SUMMARY
C
C                              CDM-2.0
C                                 |
C           |_____________________|_________________________
C           |             |       |                        |
C         CLINT         CALQ     AREA                    POINT
C           |                     |                        |
C      _____|_____                |         _______________|_______________
C     |           |               |        |           |           |       |
C   DFAULT      VIRTX          SIGMAZ    VIRTX       PLRISE      STDW    SIGMA
C                 |                        |
C                 |                        |
C               SIGMAZ                   SIGMAZ
C
C         THE SUBROUTINE ORDER IN THE LISTING IS AS FOLLOWS:  CLINT,
C         DFAULT, CALQ, AREA, POINT, PLRISE, STDW, VIRTX, SIGMAZ, AND
C         BLOCK DATA.
C
C
C * * *    INPUT/OUTPUT INFORMATION
C
C                                                    I/O UNIT
C         FORTRAN     DATA SET
C          UNIT
C           5         CONTROL INPUT (RECORD          DISK
C                       TYPES 1-3)
C          IRD*       CONTROL INPUT (RECORD          DISK
C                       TYPES 4-18)
C                                                    PRINTER OR DISK
C          IWR*       OUTPUT LISTING                 DISK OR MAGNETIC TAPE
C          IPU*       CONCENTRATION DATA
C
C         * SEE RECORD TYPE 3 BELOW.
C
C
C
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION DX(4),DY(4),A(4),KPX(38),TCON(2),CCON(2),FRECPT(16)
C        THE PARAMETER STATEMENT PERMITS STORAGE ASSIGNMENT
C         ACCORDING TO THE NEEDS OF EACH PROBLEM.  IF THE USER'S
C         FORTRAN COMPILER DOES NOT SUPPORT PARAMETER, THE DESIRED
C         NUMBER OF NPTS, NQLIM, NASE, AND NASN WILL HAVE TO BE
```

```
C          HARDCODED.  THE BEST WAY TO DO THIS IS THROUGH GLOBAL        CDM00760
C          CHANGES WITH AN EDITOR.                                      CDM00770
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR      CDM00780
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD         CDM00790
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG          CDM00800
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR  CDM00810
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU         CDM00820
      COMMON /C6/ ICHK                                                  CDM00830
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,            CDM00840
     *              Z(NASE,NASN,3)                                      CDM00850
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)                 CDM00860
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),     CDM00870
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,   CDM00880
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)   CDM00890
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NGRAD,NSTDW,KLOW,KHIGH,   CDM00900
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF    CDM00910
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),     CDM00920
     *               TTITLE(3)                                          CDM00930
C                                                                       CDM00940
C         FORM OF INPUT TO CDM-2.0 (BATCH)                              CDM00950
C                                                                       CDM00960
C     VARIABLE                                                          CDM00970
C     NAME   COLMN  FRMT            DESCRIPTION                         CDM00980
C                                                                       CDM00990
C  RECORD TYPE 1 * * * RUN TITLE * * *                                  CDM01000
C                                                                       CDM01010
C     HEADNG 1-80   20A4            DESCRIPTION OR TITLE OF MODEL RUN.  CDM01020
C                                                                       CDM01030
C  RECORD TYPE 2 * * * POLLUTANTS * * *                                 CDM01040
C                                                                       CDM01050
C     NSO2    1      I1             POLLUTANT NUMBER FOR SO2            CDM01060
C                                     = 0, SO2 NOT CONSIDERED IN RUN    CDM01070
C                                     = 1, POLLUTANT 1 IS SO2           CDM01080
C                                     = 2, POLLUTANT 2 IS SO2           CDM01090
C     PNAME  5-12   2A4             NAMES OF TWO POLLUTANTS TO BE MODELECDM01100
C                                                                       CDM01110
C  RECORD TYPE 3 * * * PARAMETERS * * *                                 CDM01120
C                                                                       CDM01130
C     AROS   1-8   2A4  AAAA        ALPHA AREA ROSE OUTPUT ID           CDM01140
C     PROS   9-16  2A4  AAAA        ALPHA POINT ROSE OUTPUT ID          CDM01150
C     IRUN  17-21  I5   XXXXX       USER DEFINED RUN ID NUMBER          CDM01160
C     NLIST 22-26  I5   XXXXX       CONTROL FOR PRINTED OUTPUT          CDM01170
C                                   IF NLIST > 0 ECHO SETUP INFO + METEOCDM01180
C                                                LIST CONC. RESULTS     CDM01190
C                                   IF NLIST = 0 ECHO SETUP INFO + METEOCDM01200
C                                                ECHO SOURCE INFO INPUT CDM01210
C                                                LIST CONC. RESULTS     CDM01220
C                                   IF NLIST < 0 LIST ONLY CONC. RESULTSCDM01230
C     IRD   27-31  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (READ)  CDM01240
C     IWR   32-36  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (PRINTERCDM01250
C     IPU   37-41  I5   XXXXX       FORTRAN LOGICAL UNIT NUMBER (PUNCH) CDM01260
C     CA    42-59 2F9.0 XXXXXX.XX   INTERCEPT OF CALIBRATION            CDM01270
C     CB    60-77 2F9.0 XXXXXX.XX   SLOPE OF CALIBRATION                CDM01280
C                                                                       CDM01290
C  RECORD TYPE 4 * * * PARAMETERS * * *                                 CDM01300
C                                                                       CDM01310
C     N1636  (FREE FORMAT)          NUMBER OF WIND DIRECTIONS USED IN   CDM01320
C                                   METEOROLOGICAL JOINT FREQUENCY      CDM01330
C                                   FUNCTION (EITHER 16 OR 36).         CDM01340
C                                                                       CDM01350
C     NP50   (FREE FORMAT)          INITIAL DISPERSION OPTION           CDM01360
C                                     < OR = 0, NO ACTION TAKEN ON POINTCDM01370
C                                       SOURCES WITH RELEASE HEIGHTS    CDM01380
C                                       BELOW 50 M.                     CDM01390
C                                     > 0, INITIALLY DISPERSE AS        CDM01400
C                                       DESCRIBED IN CDM-2.0 USER'S GUIDCDM01410
C                                                                       CDM01420
C     NPDH   (FREE FORMAT)          BUOYANCY-INDUCED DISPERSION OPTION  CDM01430
C                                     < OR = 0, NO ACTION TAKEN         CDM01440
C                                     > 0, INCLUDE BUOYANCY INDUCED     CDM01450
C                                       DISPERSION EFFECTS, PASQUILL    CDM01460
C                                       (1976), IN POINT SOURCE DISPER- CDM01470
C                                       SION AND SET PLUME AT FINAL     CDM01480
C                                       EFFECTIVE HEIGHT FOR ALL        CDM01490
C                                       DISTANCES.                      CDM01500
```

```
C                                                                       CDM01510
C     NSTDW  (FREE FORMAT)          STACK DOWNWASH OPTION               CDM01520
C                                     < 0, BJORKLUND AND BOWERS (1982)  CDM01530
C                                          STACK DOWNWASH CONSIDERED    CDM01540
C                                     = 0, NO ACTION TAKEN              CDM01550
C                                     > 0, BRIGGS (1973) STACK DOWNWASH CDM01560
C                                          CONSIDERED                   CDM01570
C                                                                       CDM01580
C     NGRAD  (FREE FORMAT)          GRADUAL PLUME RISE OPTION           CDM01590
C                                     < OR = 0, NO ACTION TAKEN         CDM01600
C                                    > 0, GRADUAL PLUME RISE CONSIDEREDCDM01610
C                                                                       CDM01620
C     FAC    (FREE FORMAT)          EFFLUENT RISE FOR AREA SOURCES      CDM01630
C                                                                       CDM01640
C     RCEPTZ (FREE FORMAT)          HEIGHT (M) ABOVE GROUND OF ALL      CDM01650
C                                   RECEPTORS                           CDM01660
C                                                                       CDM01670
C     KELVIN (FREE FORMAT)          UNITS FLAG FOR STACK TEMPERATURE    CDM01680
C                                     < 0, DEGREES F                    CDM01690
C                                     = 0, DEGREES C                    CDM01700
C                                     > 0, DEGREES KELVIN               CDM01710
C                                                                       CDM01720
C     NDEF   (FREE FORMAT)          DEFAULT OPTION                      CDM01730
C                                    < OR = 0, NO ACTION TAKEN          CDM01740
C                                    > 0, IMPLEMENT DEFAULT OPTION      CDM01750
C                                                                       CDM01760
C  RECORD TYPE 5 * * * PARAMETERS * * *                                 CDM01770
C                                                                       CDM01780
C     KLOW   (FREE FORMAT)          DISPERSION PARAMETER SCHEME FOR AREACDM01790
C                                   SOURCES.  SEE COMMENTS ON KTYPE IN  CDM01800
C                                   SUBROUTINE SIGMAZ.  THE CDM-2.0 USERCDM01810
C                                   GUIDE ALSO DESCRIBES THIS PARAMETER.CDM01820
C                                                                       CDM01830
C     ICA    (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING    CDM01840
C                                   DISPERSION CURVES (AS DEFINED BY    CDM01850
C                                   KLOW) TO BE USED FOR THE SIX        CDM01860
C                                   STABILITY CATEGORIES SUMMARIZED IN  CDM01870
C                                   THE JOINT FREQUENCY FUNCTION.       CDM01880
C                                                                       CDM01890
C  RECORD TYPE 6 * * * PARAMETERS * * *                                 CDM01900
C                                                                       CDM01910
C     KHIGH  (FREE FORMAT)          DISPERSION PARAMETER SCHEME FOR POINCDM01920
C                                   SOURCES.  SEE COMMENTS ON KTYPE IN  CDM01930
C                                   SUBROUTINE SIGMAZ.  THE CDM-2.0 USERCDM01940
C                                   GUIDE ALSO DESCRIBES THIS PARAMETER.CDM01950
C                                                                       CDM01960
C     ICP    (FREE FORMAT)          ARRAY OF SIX (6) VALUES DEFINING    CDM01970
C                                   DISPERSION CURVES (AS DEFINED BY    CDM01980
C                                   KHIGH) TO BE USED FOR THE SIX       CDM01990
C                                   STABILITY CATEGORIES SUMMARIZED IN  CDM02000
C                                   THE JOINT FREQUENCY FUNCTION.       CDM02010
C                                                                       CDM02020
C  RECORD TYPE 7 * * * PARAMETERS * * *                                 CDM02030
C                                                                       CDM02040
C     DELR     1-6  F6.0 XXXXX.     RADIAL INCREMENT (M)                CDM02050
C     RAT     7-12  F6.0 XXX.XX     LENGTH OF A BASIC EMISSION GRID     CDM02060
C                                   SQUARE IN USER UNITS                CDM02070
C     CV     13-18  F6.0 XXXX.X     CONVERSION FACTOR,                  CDM02080
C                                   CV * RAT = EMISSION GRID INTERVAL (MCDM02090
C     XG     19-24  F6.0 XXX.XX     X MAP COORD. OF THE SW CORNER OF THECDM02100
C                                   EMISSION GRID ARRAY                 CDM02110
C     YG     25-30  F6.0 XXX.XX     Y MAP COORD. OF THE SW CORNER OF THECDM02120
C                                   EMISSION GRID ARRAY                 CDM02130
C     TOA    31-36  F6.0 XXX.XX     MEAN ATMOSPHERIC TEMPERATURE (DEG C)CDM02140
C     TXX    37-42  F6.0 XXXXX.     WIDTH OF BASIC EMISSION SQUARE (M)  CDM02150
C                                                                       CDM02160
C  RECORD TYPE 8 * * * PARAMETERS * * *                                 CDM02170
C                                                                       CDM02180
C     DINT     1-6  F6.0 XXXXX.     NUMBER OF SEGMENTS DESIRED IN DELTA CDM02190
C                                   DEGREE SECTORS.  RANGES FROM 2 TO 20CDM02200
C                                   INCLUSIVE.                          CDM02210
C     YD      7-12  F6.0 XXX.XX     RATIO OF THE DAYTIME EMISSION RATE  CDM02220
C                                   TO THE AVERAGE 24-HOUR EMISSION RATECDM02230
C     YN     13-18  F6.0 XXX.XX     RATIO OF THE NIGHTTIME EMISSION RATECDM02240
C                                   TO THE AVERAGE 24-HOUR EMISSION RATECDM02250
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C     SZA   19-54 6F6.0 XXX.XX     INITIAL SIGMA-Z FOR AREA SOURCES (M)CDM02260
C     GB    55-66 2F6.0 XXXXX.     DECAY HALF-LIFE (HR) FOR THE TWO    CDM02270
C                                  POLLUTANTS                          CDM02280
C                                                                      CDM02290
C  RECORD TYPE 9 * * * WIND PROFILE EXPONENTS * * *                    CDM02300
C                                                                      CDM02310
C     UE      (FREE FORMAT)        ARRAY OF SIX (6) VALUES DEFINING WINCDM02320
C                                  PROFILE EXPONENTS TO BE ASSOCIATED  CDM02330
C                                  WITH THE SIX STABILITY CATEGORIES   CDM02340
C                                  SUMMARIZED IN THE JOINT FREQUENCY   CDM02350
C                                  FUNCTION.                           CDM02360
C                                                                      CDM02370
C  RECORD TYPE 10 * * * WIND SPEEDS * * *                              CDM02380
C                                                                      CDM02390
C     U       (FREE FORMAT)        ARRAY OF SIX (6) VALUES DEFINING WINCDM02400
C                                  SPEEDS (M/SEC) TO BE ASSOCIATED WITHCDM02410
C                                  THE SIX WIND SPEED CATEGORIES SUMMARCDM02420
C                                  IZED IN THE JOINT FREQUENCY FUNCTIONCDM02430
C                                  TYPICALLY THE HARMONIC AVERAGE WIND CDM02440
C                                  SPEED IS USED.                      CDM02450
C                                                                      CDM02460
C  RECORD TYPE 11 * * * MIXING HEIGHTS * * *                           CDM02470
C                                                                      CDM02480
C     HL      (FREE FORMAT)        ARRAY OF SIX (6) VALUES DEFINING    CDM02490
C                                  MIXING HEIGHTS TO BE ASSOCIATED WITHCDM02500
C                                  THE SIX STABILITY CATEGORIES SUMMAR-CDM02510
C                                  IZED IN THE JOINT FREQUENCY FUNCTIONCDM02520
C                                                                      CDM02530
C  RECORD TYPE 12 * * * FORMAT STATEMENT * * *                         CDM02540
C                                                                      CDM02550
C     FMETEO 1-64  16A4            FORMAT STATEMENT, INCLUDING BEGINNINCDM02560
C                                  AND ENDING PARENTHESIS, FOR THE     CDM02570
C                                  METEOROLOGICAL JOINT FREQUENCY      CDM02580
C                                  FUNCTION.  OLD CDM FORMAT WAS,      CDM02590
C                                  (9X,6F9.0)                          CDM02600
C                                                                      CDM02610
C  RECORD TYPE 13 * * * JOINT FREQUENCY FUNCTION                       CDM02620
C                                                                      CDM02630
C     F       (SEE CARD TYPE 12)     F(I,J,K)     (PERCENT)            CDM02640
C                                                                      CDM02650
C  RECORD TYPE 14 * * * FORMAT STATEMENT * * *                         CDM02660
C                                                                      CDM02670
C     FSOURC 1-64  16A4            FORMAT STATEMENT, INCLUDING BEGINNINCDM02680
C                                  AND ENDING PARENTHESIS, FOR THE     CDM02690
C                                  SOURCE INVENTORY.  OLD CDM FORMAT WACDM02700
C                                  (F6.0,2F7.0,2F8.0,F7.0,F5.0,2F7.0,  CDM02710
C                                  F5.0)                               CDM02720
C                                                                      CDM02730
C  RECORD TYPE 15 *** SOURCE INVENTORY (VARIABLE NUMBER OF RECORDS) ***CDM02740
C                                                                      CDM02750
C     X      (SEE RECORD TYPE 14)  X MAP COORD OF SOURCE (RE USER GUIDECDM02760
C     Y                "           Y MAP COORD OF SOURCE (RE USER GUIDECDM02770
C     TX               "           WIDTH OF AREA SOURCE.  ENTER ZERO ORCDM02780
C                                  LEAVE BLANK FOR POINT SOURCES.      CDM02790
C     S1               "           EMISSION RATE OF POLLUTANT 1 (G/SEC)CDM02800
C     S2               "           EMISSION RATE OF POLLUTANT 2 (G/SEC)CDM02810
C     SH               "           SOURCE HEIGHT (M)                   CDM02820
C     D                "           STACK DIAMETER (M).  LEAVE BLANK FORCDM02830
C                                  AREA SOURCES.                       CDM02840
C     VS               "           EXIT VELOCITY (M/SEC).  LEAVE BLANK CDM02850
C                                  FOR AREA SOURCES.                   CDM02860
C     T                "           STACK GAS TEMPERATURE (C).  LEAVE   CDM02870
C                                  BLANK FOR AREA SOURCES.             CDM02880
C     SA               "           PLUME RISE OPTION,                  CDM02890
C                                    < OR = 0, BRIGGS PLUME RISE       CDM02900
C                                    > 0, ENTER PRODUCT OF PLUME RISE  CDM02910
C                                      AND WIND SPEED (M**2/SEC)       CDM02920
C                                                                      CDM02930
C  RECORD TYPE 16 * * * BLANK SENTINEL CARD * * *                      CDM02940
C                                                                      CDM02950
C  RECORD TYPE 17 * * * FORMAT STATEMENT * * *                         CDM02960
C                                                                      CDM02970
C     FRECPT 1-64  16A4            FORMAT STATEMENT, INCLUDING BEGINNINCDM02980
C                                  AND ENDING PARENTHESIS, FOR THE     CDM02990
C                                  RECEPTOR CARDS.  OLD CDM FORMAT WAS,CDM03000
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C                                 (2F8.2,14X,I4,3X,I4,I5)             CDM03010
C                                                                     CDM03020
C  RECORD TYPE 18 *** RECEPTOR CARDS (VARIABLE NUMBER OF RECORDS) *** CDM03030
C                                                                     CDM03040
C     RX      (SEE RECORD TYPE 17)  X MAP COORD. OF THE RECEPTOR      CDM03050
C     RY              "             Y MAP COORD. OF THE RECEPTOR      CDM03060
C     KPX9            "             OBSERVED CONC. OF POLLUTANT 1 AT THECDM03070
C                                   RECEPTOR, IF KNOWN                CDM03080
C     KPX10           "             OBSERVED CONC. OF POLLUTANT 2 AT THECDM03090
C                                   RECEPTOR, IF KNOWN                CDM03100
C     NROSE           "             OPTION FOR POLLUTANT CONC. ROSES  CDM03110
C                                      > 0, PRINT CONCENTRATION ROSES CDM03120
C                                      < OR = 0, NO CONCENTRATION ROSES CDM03130
C                                                                     CDM03140
C                                                                     CDM03150
      CALL CLINT(ICOND)                                               CDM03160
C                                                                     CDM03170
      IF (ICOND .EQ. 0) GO TO 20                                      CDM03180
         WRITE(IWR,10)                                                CDM03190
   10    FORMAT('0*** EXECUTION TERMINATED.')                         CDM03200
         GO TO 620                                                    CDM03210
   20 DELO2 = DELTA/2.0                                               CDM03220
C                                                                     CDM03230
C         READ RECORD TYPE 17.                                        CDM03240
C                                                                     CDM03250
      READ(IRD,30) FRECPT                                             CDM03260
   30 FORMAT(16A4)                                                    CDM03270
C                                                                     CDM03280
C         INITIALIZE CONCENTRATION ARRAYS                             CDM03290
C                                                                     CDM03300
   40 DO 60 I=1,2                                                     CDM03310
         DO 50 IDUM=1,6                                               CDM03320
            PPAR(I,IDUM) = 0.0                                        CDM03330
            APAR(I,IDUM) = 0.0                                        CDM03340
   50    CONTINUE                                                     CDM03350
         ABAR(I)=0.                                                   CDM03360
         PBAR(I)=0.                                                   CDM03370
         DO 55 K=1,N1636                                              CDM03380
            AROSE(K,I)=0.                                             CDM03390
            PROSE(K,I)=0.                                             CDM03400
   55    CONTINUE                                                     CDM03410
   60 CONTINUE                                                        CDM03420
C                                                                     CDM03430
C         READ RECORD TYPE 18 (RECEPTOR INFORMATION).                 CDM03440
C          AT END OF FILE STOP EXECUTION.                             CDM03450
C                                                                     CDM03460
      READ(IRD,FRECPT,END=620)RX,RY,KPX(9),KPX(10),NROSE              CDM03470
C         RX:      X MAP COORD. OF THE RECEPTOR                       CDM03480
C         RY:      Y MAP COORD. OF THE RECEPTOR                       CDM03490
C         KPX(9):  OBSERVED CONC. OF POLLUTANT 1 AT THE RECEPTOR, IF  CDM03500
C                      KNOWN                                          CDM03510
C         KPX(10): OBSERVED CONC. OF POLLUTANT 2 AT THE RECEPTOR, IF  CDM03520
C                      KNOWN                                          CDM03530
C         NROSE:   OPTION FOR POLLUTANT CONCENTRATION ROSES           CDM03540
C                                                                     CDM03550
       ICHK = 0                                                       CDM03560
C                                                                     CDM03570
C          ICHK IS USED IN CALQ TO CONTROL THE PRINTING OF THE        CDM03580
C           WARNING MESSAGE ABOUT EXCEEDING 100 ARCS.  WE SET ICHK    CDM03590
C           TO ZERO WHENEVER WE READ IN A NEW RECEPTOR.  A            CDM03600
C           WARNING MESSAGE IS PRINTED ONLY WHEN NEEDED AND ONLY      CDM03610
C           WHEN ICHK = 0.  WHEN THE MESSAGE IS PRINTED, ICHK IS      CDM03620
C           SET TO THE VALUE OF 1 IN CALQ.  IN THIS MANNER, WE        CDM03630
C           PRINT THE WARNING ONLY ONCE PER RECEPTOR EVEN IF          CDM03640
C           MORE THAN 100 ARCS IS CALLED FOR IN MORE THAN ONE         CDM03650
C           SECTOR.                                                   CDM03660
C                                                                     CDM03670
C         CONVERT COORDINATES TO EMISSION GRID UNITS                  CDM03680
       RI=(RX-XG)/RAT+0.5                                             CDM03690
       RJ=(RY-YG)/RAT+0.5                                             CDM03700
       IF(NROSE.GE.1) GO TO 110                                       CDM03710
       IPG=IPG+1                                                      CDM03720
C         START NEW PAGE IF LINE COUNT GE 50                          CDM03730
       IF(IPG.LT.44) GO TO 110                                        CDM03740
       IPG=0                                                          CDM03750
      WRITE(IWR,70)IVER,IRUN,HEADNG                                     CDM03760
   70 FORMAT('1',35X,'CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0',/ CDM03770
     *        1X,48X,'CODE VERSION ',I5,/                               CDM03780
     *        1X,53X,'RUN ',I5,//,                                      CDM03790
     *        1X,20A4,//)                                               CDM03800
      WRITE(IWR,80)                                                     CDM03810
   80 FORMAT(1X,39X,'CONCENTRATIONS (MICROGRAMS/CU. METER)',//)         CDM03820
      WRITE(IWR,90) PNAME(1),PNAME(2),PNAME(1),PNAME(2),PNAME(1),       CDM03830
     *              PNAME(2),PNAME(1),PNAME(2),PNAME(1),PNAME(2)        CDM03840
   90 FORMAT(1X,22X,'AREA  SOURCES      POINT  SOURCES      -----TOTAL',CDM03850
     *       '-----      --CALIBRATED--      ---OBSERVED---',/          CDM03860
     *       1X,'X COORD   Y COORD',5X,5(A4,5X,A4,7X),/)                CDM03870
C                                                                       CDM03880
C         INITIALIZE SECTOR DIRECTION                                   CDM03890
C          K: PROGRESSES 1 THROUGH N1636 CONTROLLING SECTOR DIRECTION   CDM03900
C                                                                       CDM03910
  110 K=1                                                               CDM03920
C                                                                       CDM03930
C         IF THERE ARE NO AREA SOURCES TO EVALUATE GO TO 340 AND CHECK  CDM03940
C          FOR POINT SOURCES                                            CDM03950
C                                                                       CDM03960
      IF(IAS.LT.1) GO TO 340                                            CDM03970
C                                                                       CDM03980
C         THERE ARE AREA SOURCES TO EVALUATE.                           CDM03990
C          DETERMINE MAXIMUM AND MINIMUM DISTANCES FROM THE RECEPTOR    CDM04000
C          TO THE EMISSION GRID BOUNDARIES.                             CDM04010
C                                                                       CDM04020
      DX(1)=(IX-0.5)-RI                                                 CDM04030
      DX(2)=(IXX+0.5)-RI                                                CDM04040
      DX(3)=DX(2)                                                       CDM04050
      DX(4)=DX(1)                                                       CDM04060
      DY(1)=(IY-0.5)-RJ                                                 CDM04070
      DY(2)=DY(1)                                                       CDM04080
      DY(3)=(IYY+0.5)-RJ                                                CDM04090
      DY(4)=DY(3)                                                       CDM04100
      TX=(DX(1)*DX(1)+DY(1)*DY(1))**0.5                                 CDM04110
      TN=TX                                                             CDM04120
      TM=(DX(2)*DX(2)+DY(1)*DY(1))**0.5                                 CDM04130
      IF(TM.GT.TX) TX=TM                                                CDM04140
      IF(TM.LT.TN) TN=TM                                                CDM04150
      TM=(DX(2)*DX(2)+DY(3)*DY(3))**0.5                                 CDM04160
      IF(TM.GT.TX) TX=TM                                                CDM04170
      IF(TM.LT.TN) TN=TM                                                CDM04180
      TM=(DX(1)*DX(1)+DY(3)*DY(3))**0.5                                 CDM04190
      IF(TM.GT.TX) TX=TM                                                CDM04200
      IF(TM.LT.TN) TN=TM                                                CDM04210
      MX=TX/DR                                                          CDM04220
C                                                                       CDM04230
C         IF THE RECEPTOR IS OUTSIDE THE EMISSION GRID BOUNDARIES THEN  CDM04240
C           GO TO 120                                                   CDM04250
C                                                                       CDM04260
      IF(RI+0.5.LT.IX.OR.RI-0.5.GT.IXX) GO TO 120                       CDM04270
      IF(RJ+0.5.LT.IY.OR.RJ-0.5.GT.IYY) GO TO 120                       CDM04280
C                                                                       CDM04290
C         SET FLAG (IB) TO REMEMBER RECEPTOR IS WITHIN GRID BOUNDARIES  CDM04300
C                                                                       CDM04310
      IB=1                                                              CDM04320
      MN=1                                                              CDM04330
      GO TO 330                                                         CDM04340
C                                                                       CDM04350
C         SET FLAG (IB) TO REMEMBER RECEPTOR IS OUTSIDE GRID BOUNDARIESCDM04360
C                                                                       CDM04370
  120 IB=2                                                              CDM04380
C                                                                       CDM04390
C         DETERMINE MINIMUM DISTANCE FROM RECEPTOR TO AREA SOURCES      CDM04400
C                                                                       CDM04410
      TMN=TN/DR                                                         CDM04420
      TXI=0.                                                            CDM04430
      TNI=400.                                                          CDM04440
      DO 240 I=1,4                                                      CDM04450
         IF(DX(I))130,150,190                                           CDM04460
  130    IF(DY(I).EQ.0.) GO TO 140                                      CDM04470
         TA(I)=ATAN(DY(I)/DX(I))*RAD+180.                               CDM04480
         GO TO 230                                                      CDM04490
  140    TA(I)=180.                                                     CDM04500
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         GO TO 230                                                     CDM04510
  150    IF(DY(I))160,170,180                                          CDM04520
  160    TA(I)=270.                                                    CDM04530
         GO TO 230                                                     CDM04540
  170    TA(I)=0.                                                      CDM04550
         GO TO 230                                                     CDM04560
  180    TA(I)=90.                                                     CDM04570
         GO TO 230                                                     CDM04580
  190    IF(DY(I))200,210,220                                          CDM04590
  200    TA(I)=ATAN(DY(I)/DX(I))*RAD+360.                              CDM04600
         GO TO 230                                                     CDM04610
  210    TA(I)=360.                                                    CDM04620
         GO TO 230                                                     CDM04630
  220    TA(I)=ATAN(DY(I)/DX(I))*RAD                                   CDM04640
  230    IF(TA(I).GT.TXI) TXI=TA(I)                                    CDM04650
         IF(TA(I).LT.TNI) TNI=TA(I)                                    CDM04660
  240 CONTINUE                                                         CDM04670
      TDIF=TXI-TNI                                                     CDM04680
  250 DO 260 I=1,4                                                     CDM04690
  260     A(I)=TA(I)                                                   CDM04700
      TX=TXI                                                           CDM04710
      TN=TNI                                                           CDM04720
      IF(TDIF.GT.180.) GO TO 290                                       CDM04730
      TM=90.-TK(K)                                                     CDM04740
      IF(TM.LT.0.) TM=TM+360.                                          CDM04750
  270 IF(TM.GE.TN-DELO2) GO TO 280                                     CDM04760
      IF(TM.GE.DELO2) GO TO 340                                        CDM04770
      TM=TM+360.                                                       CDM04780
  280 IF(TM-(TX+DELO2))320,320,340                                     CDM04790
  290 TM=180.-TK(K)                                                    CDM04800
      IF(TM.LT.0.) TM=TM+360.                                          CDM04810
  300 TX=0.                                                            CDM04820
      TN=400.                                                          CDM04830
      DO 310 I=1,4                                                     CDM04840
          A(I)=A(I)+90.                                                CDM04850
          IF(A(I).GE.360.) A(I)=A(I)-360.                              CDM04860
          IF(A(I).GT.TX) TX=A(I)                                       CDM04870
          IF(A(I).LT.TN) TN=A(I)                                       CDM04880
  310 CONTINUE                                                         CDM04890
      IF(TX-TN.LE.180.) GO TO 270                                      CDM04900
      TM=270.-TK(K)                                                    CDM04910
      IF(TM.LT.0.) TM=TM+360.                                          CDM04920
      GO TO 300                                                        CDM04930
  320 DIF=(TX-TN)/(2.*RAD)                                             CDM04940
      MN=TMN*COS(DIF)                                                  CDM04950
C         NEGATE POSSIBLE ERROR IN COSINE FUNCTION.                    CDM04960
      L=MOD(MN,INC(4))                                                 CDM04970
      IF(L.LE.0) L=INC(4)                                              CDM04980
      MN=MN-L                                                          CDM04990
C         MN ALWAYS EQUALS 1 IF RECEPTOR WITHIN AREA SOURCE GRID       CDM05000
      IF(MN.LT.1) MN=1                                                 CDM05010
  330 N=MN                                                             CDM05020
C                                                                      CDM05030
C         CALCULATE THE AREA SOURCE VECTOR                             CDM05040
C                                                                      CDM05050
      CALL CALQ                                                        CDM05060
C                                                                      CDM05070
C         CALCULATE SECTOR CONCENTRATION FROM THE AREA SOURCE VECTOR   CDM05080
C                                                                      CDM05090
      CALL AREA                                                        CDM05100
C                                                                      CDM05110
C         IF NO POINT SOURCES, GO TO NEXT SECTOR                       CDM05120
C                                                                      CDM05130
  340 IF(IPS.LE.0) GO TO 350                                           CDM05140
C                                                                      CDM05150
C         CALCULATE SECTOR CONCENTRATION FROM THE POINT SOURCES        CDM05160
C                                                                      CDM05170
      CALL POINT                                                       CDM05180
C                                                                      CDM05190
C         IF ALL THE SECTORS HAVE BEEN ANALYZED THEN PRINT AND STORE   CDM05200
C          THE RESULTS                                                 CDM05210
C                                                                      CDM05220
  350 IF(K.GE.N1636) GO TO 370                                         CDM05230
C                                                                      CDM05240
C         NEXT DIRECTION SECTOR. K LOOPS THROUGH N1636 SECTORS.        CDM05250
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C                                                                       CDM05260
      K=K+1                                                             CDM05270
      DO 360 I=1,2                                                      CDM05280
         AROSE(K,I)=0.                                                  CDM05290
         PROSE(K,I)=0.                                                  CDM05300
  360 CONTINUE                                                          CDM05310
C                                                                       CDM05320
C         IF NO AREA SOURCES, CHECK POINT SOURCES                       CDM05330
C                                                                       CDM05340
      IF(IAS.LT.1) GO TO 340                                            CDM05350
C                                                                       CDM05360
C         BRANCH TO 330 OR 250 DEPENDS ON WHETHER RECEPTOR INSIDE (IB=1 CDM05370
C          OR OUTSIDE (IB=2) AREA SOURCE                                CDM05380
C                                                                       CDM05390
      GO TO (330,250),IB                                                CDM05400
C                                                                       CDM05410
C         PRINT AND STORE RESULTS                                       CDM05420
C                                                                       CDM05430
  370 DO 380 I=1,2                                                      CDM05440
         TCON(I)=PBAR(I)+ABAR(I)                                        CDM05450
         CCON(I)=CA(I)+CB(I)*TCON(I)                                    CDM05460
  380 CONTINUE                                                          CDM05470
C         TCON: TOTAL CONCENTRATION                                     CDM05480
C         CCON: CALIBRATED CONCENTRATION                                CDM05490
      IF(NROSE .LT. 1) GO TO 390                                        CDM05500
      WRITE(IWR,70)IVER,IRUN,HEADNG                                     CDM05510
      WRITE(IWR,80)                                                     CDM05520
      WRITE(IWR,90) PNAME(1),PNAME(2),PNAME(1),PNAME(2),PNAME(1),       CDM05530
     *              PNAME(2),PNAME(1),PNAME(2),PNAME(1),PNAME(2)        CDM05540
  390 WRITE(IWR,400)RX,RY,ABAR,PBAR,TCON,CCON,KPX(9),KPX(10)            CDM05550
  400 FORMAT(1X,2(F7.2,3X),4(F6.1,3X,F6.1,5X),2X,2(I4,5X))              CDM05560
C         ABAR: CONTRIBUTION FROM AREA SOURCES                          CDM05570
C         PBAR: CONTRIBUTION FROM POINT SOURCES                         CDM05580
C         KPX:  CARD OUTPUT VECTOR                                      CDM05590
      KPX(1)=ABAR(1)+0.5                                                CDM05600
      KPX(2)=ABAR(2)+0.5                                                CDM05610
      KPX(3)=PBAR(1)+0.5                                                CDM05620
      KPX(4)=PBAR(2)+0.5                                                CDM05630
      KPX(5)=TCON(1)+0.5                                                CDM05640
      KPX(6)=TCON(2)+0.5                                                CDM05650
      KPX(7)=CCON(1)+0.5                                                CDM05660
      KPX(8)=CCON(2)+0.5                                                CDM05670
      WRITE(IPU,410)RX,RY,IRUN,(KPX(L),L=1,10)                          CDM05680
  410 FORMAT(1X,2F10.2,I5,'I',10I4)                                     CDM05690
      IF(NROSE.LT.1) GO TO 40                                           CDM05700
C         WRITE OUT PARTIAL CONCENTRATIONS ESTIMATED FOR                CDM05710
C          EACH STABILITY CATEGORY (LIST SEPARATELY THE                 CDM05720
C          CONTRIBUTIONS FROM POINT AND AREA SOURCES).                  CDM05730
C                                                                       CDM05740
      WRITE(IWR,430)                                                    CDM05750
  430 FORMAT(//,1X,41('*'),' AVERAGE CONCENTRATIONS BY STABILITY ',     CDM05760
     *       41('*'),//)                                                CDM05770
      WRITE(IWR,440)(IDUM,IDUM=1,6)                                     CDM05780
  440 FORMAT(1X,38X,'TYPE OF   -------------STABILITY CATEGORY',        CDM05790
     *       '--------------',/,                                        CDM05800
     *       1X,26X,'POLLUTANT   SOURCE',6(6X,I2)/)                     CDM05810
      KPX(37)=RX*100.                                                   CDM05820
      KPX(38)=RY*100.                                                   CDM05830
      DO 470 JDUM=1,2                                                   CDM05840
         WRITE(IWR,450) JDUM,PNAME(JDUM),(APAR(JDUM,IDUM),IDUM=1,6)     CDM05850
         WRITE(IPU,455) AROS(JDUM),(APAR(JDUM,IDUM),IDUM=1,6),KPX(37),  CDM05860
     *                  KPX(38)                                         CDM05870
  450    FORMAT(1X,26X,I2,' (',A4,')',4X,'AREA ',1X,6(2X,F6.1),/)       CDM05880
  455    FORMAT(1X,A4,6F7.1,2I8)                                        CDM05890
         WRITE(IWR,460) JDUM,PNAME(JDUM),(PPAR(JDUM,IDUM),IDUM=1,6)     CDM05900
         WRITE(IPU,455) PROS(JDUM),(PPAR(JDUM,IDUM),IDUM=1,6),KPX(37),  CDM05910
     *                  KPX(38)                                         CDM05920
  460    FORMAT(1X,26X,I2,' (',A4,')',4X,'POINT',1X,6(2X,F6.1),//)      CDM05930
  470 CONTINUE                                                          CDM05940
      IBUM = 8                                                          CDM05950
      IF(N1636.EQ.36) IBUM = 12                                         CDM05960
      WRITE(IWR,480)                                                    CDM05970
  480 FORMAT(/,1X,42('*'),' AREA ROSES (MICROGRAMS/CU. METER) ',        CDM05980
     *       42('*'),//)                                                CDM05990
      IF (N1636 .EQ. 16) WRITE(IWR,490)(D16(I),I=1,2*N1636,2)           CDM06000
  490 FORMAT(1X,6X,'POLLUTANT',5X,4(A4,A4,3X,A4,1X,A4,4X)/)              CDM06010
      IF (N1636 .EQ. 36) WRITE(IWR,500)(ISECTR,ISECTR+18, ISECTR=1,18) CDM06020
  500 FORMAT(1X,'POLLUTANT',3X,18(I2,'&',I2,1X)/)                       CDM06030
      DO 550 J=1,2                                                      CDM06040
         DO 510 I=1,N1636                                               CDM06050
            KPX(I)=AROSE(I,J)+0.5                                       CDM06060
  510    CONTINUE                                                       CDM06070
         IJ = 0                                                         CDM06080
  520    IJ = IJ + 1                                                    CDM06090
         ISTART = (IJ-1)*IBUM + 1                                       CDM06100
         IFIN = (IJ-1)*IBUM + IBUM                                      CDM06110
         WRITE(IPU,560) AROS(J),(KPX(I),I=ISTART,IFIN),KPX(37),KPX(38) CDM06120
         IF(IFIN.LT.N1636) GO TO 520                                    CDM06130
         IF (N1636 .EQ. 16) WRITE(IWR,530)J,(KPX(I),I=1,N1636)          CDM06140
  530    FORMAT(1X,10X,I1,5X,16I6,/)                                    CDM06150
         IF (N1636 .EQ. 36) WRITE(IWR,540)J,(KPX(I),I=1,N1636/2),       CDM06160
     *                               (KPX(I),I=N1636/2+1,N1636)         CDM06170
  540    FORMAT(1X,4X,I1,6X,18I6,/,1X,11X,18I6,/)                       CDM06180
  550 CONTINUE                                                          CDM06190
  560 FORMAT(1X,A4,8I5,2I8)                                             CDM06200
      WRITE(IWR,570)                                                    CDM06210
  570 FORMAT(/,1X,41('*'),' POINT ROSES (MICROGRAMS/CU. METER) ',       CDM06220
     *       42('*'),//)                                                CDM06230
      IF (N1636 .EQ. 16) WRITE(IWR,490)(D16(I),I=1,2*N1636,2)           CDM06240
      IF (N1636 .EQ. 36) WRITE(IWR,500)(ISECTR,ISECTR+18, ISECTR=1,18) CDM06250
      DO 600 L=1,2                                                      CDM06260
         DO 580 K=1,N1636                                               CDM06270
            KPX(K)=PROSE(K,L)+0.5                                       CDM06280
  580    CONTINUE                                                       CDM06290
         IJ = 0                                                         CDM06300
  590    IJ = IJ + 1                                                    CDM06310
         ISTART = (IJ-1)*IBUM + 1                                       CDM06320
         IFIN = (IJ-1)*IBUM + IBUM                                      CDM06330
         WRITE(IPU,560) PROS(L),(KPX(I),I=ISTART,IFIN),KPX(37),KPX(38) CDM06340
         IF(IFIN.LT.N1636) GO TO 590                                    CDM06350
         IF (N1636 .EQ. 16) WRITE(IWR,530)L,(KPX(I),I=1,N1636)          CDM06360
         IF (N1636 .EQ. 36) WRITE(IWR,540)L,(KPX(I),I=1,N1636/2),       CDM06370
     *                               (KPX(I),I=N1636/2+1,N1636)         CDM06380
  600 CONTINUE                                                          CDM06390
      WRITE(IWR,610)                                                    CDM06400
  610 FORMAT(1X,119('*'))                                               CDM06410
      IPG = 70                                                          CDM06420
C                                                                       CDM06430
C         GO BACK AND READ NEXT RECEPTOR                                CDM06440
C                                                                       CDM06450
      GO TO 40                                                          CDM06460
C                                                                       CDM06470
  620 STOP                                                              CDM06480
      END                                                               CDM06490
C                                                                       CDM06500
C***********************************************************************CDM06510
C                                                                       CDM06520
      SUBROUTINE CLINT(ICOND)                                           CDM06530
C             SUBROUTINE CLINT  (VERSION 85293), PART OF CDM-2.0.       CDM06540
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)                    CDM06550
      DIMENSION FMETEO(16),FSOURC(16),DUM(6),CURVE(7),PCURVE(6),        CDM06560
     *          ACURVE(6)                                               CDM06570
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR      CDM06580
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD         CDM06590
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG          CDM06600
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR CDM06610
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU         CDM06620
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,            CDM06630
     *              Z(NASE,NASN,3)                                      CDM06640
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)                 CDM06650
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),     CDM06660
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,   CDM06670
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)  CDM06680
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,   CDM06690
     *            PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF     CDM06700
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),     CDM06710
     *               TTITLE(3)                                          CDM06720
      DATA CURVE /'  A ',' B ',' C ',' D1 ',' D2 ','  E ',' F '/        CDM06730
      ICOND = 0                                                         CDM06740
C                                                                       CDM06750
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C         READ RECORD TYPE 1                                            CDM06760
C                                                                       CDM06770
      READ(5,5) HEADNG                                                  CDM06780
C         HEADNG:  DESCRIPTION OR TITLE OF MODEL RUN                    CDM06790
    5 FORMAT(20A4)                                                      CDM06800
C                                                                       CDM06810
C         READ RECORD TYPE 2                                            CDM06820
C                                                                       CDM06830
      READ(5,10) NSO2,PNAME                                             CDM06840
C         NSO2:    POLLUTANT SOURCE NUMBER FOR SO2                      CDM06850
C         PNAME:   NAMES OF TWO POLLUTANTS TO BE MODELED                CDM06860
   10 FORMAT(I1,3X,2A4)                                                 CDM06870
      IF ((NSO2 .EQ. 0) .OR. (NSO2 .EQ. 1) .OR. (NSO2 .EQ. 2)) GO TO 20CDM06880
      WRITE(6,15) NSO2                                                  CDM06890
   15 FORMAT('0*** VALID VALUES FOR NSO2 ARE 0, 1, OR 2.',/,            CDM06900
     *        ' *** USER INPUT NSO2 = ',I4)                             CDM06910
      ICOND = 1                                                         CDM06920
C                                                                       CDM06930
C         READ RECORD TYPE 3                                            CDM06940
C                                                                       CDM06950
   20 READ(5,25)AROS,PROS,IRUN,NLIST,IRD,IWR,IPU,CA,CB                  CDM06960
C         AROS:   ALPHA AREA ROSE OUTPUT ID                             CDM06970
C         PROS:   ALPHA POINT ROSE OUTPUT ID                            CDM06980
C         IRUN:   USER DEFINED RUN ID NUMBER                            CDM06990
C         NLIST:  CONTROL FOR PRINTED OUTPUT                            CDM07000
C         IRD:    FORTRAN LOGICAL UNIT NUMBER (READ)                    CDM07010
C         IWR:    FORTRAN LOGICAL UNIT NUMBER (PRINTER)                 CDM07020
C         IPU:    FORTRAN LOGICAL UNIT NUMBER (PUNCH)                   CDM07030
C         CA:     INTERCEPT OF CALIBRATION                              CDM07040
C         CB:     SLOPE OF CALIBRATION                                  CDM07050
   25 FORMAT(4A4,5I5,4F9.0)                                             CDM07060
C                                                                       CDM07070
C         READ RECORD TYPE 4                                            CDM07080
C                                                                       CDM07090
      READ(IRD,*) N1636,NP50,NPDH,NSTDW,NGRAD,FAC,RCEPTZ,KELVIN,NDEF    CDM07100
C         N1636:   NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL JOINCDM07110
C                  FREQUENCY FUNCTION.                                  CDM07120
C         NP50:    INITIAL DISPERSION OPTION                            CDM07130
C         NPDH:    BUOYANCY-INDUCED DISPERSION OPTION                   CDM07140
C         NSTDW:   STACK DOWNWASH OPTION                                CDM07150
C         NGRAD:   GRADUAL PLUME RISE OPTION                            CDM07160
C         FAC:     EFFLUENT RISE OF AREA SOURCES                        CDM07170
C         RCEPTZ:  HEIGHT (M) ABOVE GROUND OF ALL RECEPTORS             CDM07180
C         KELVIN:  UNITS FLAG FOR STACK TEMPERATURE                     CDM07190
C         NDEF:    DEFAULT OPTION                                       CDM07200
      IF ((N1636 .EQ. 16) .OR. (N1636 .EQ. 36)) GO TO 40                CDM07210
      WRITE(IWR,30) N1636                                               CDM07220
   30 FORMAT('0*** VALID VALUES FOR N1636 ARE 16 OR 36.',/              CDM07230
     *        ' *** USER INPUT N1636 =',I4)                             CDM07240
      ICOND = 1                                                         CDM07250
   40 IF ((FAC .GE. 0.) .AND. (FAC .LE. 1.)) GO TO 60                   CDM07260
      WRITE(IWR,50) FAC                                                 CDM07270
   50 FORMAT('0*** VALID VALUES FOR FAC RANGE FROM 0 TO 1.',/           CDM07280
     *        ' *** USER INPUT FAC =',F6.2)                             CDM07290
      ICOND = 1                                                         CDM07300
C                                                                       CDM07310
C         READ RECORD TYPE 5                                            CDM07320
C                                                                       CDM07330
   60 READ(IRD,*) KLOW,ICA                                              CDM07340
C         KLOW:    DISPERSION PARAMETER SCHEME FOR AREA SOURCES         CDM07350
C         ICA:     ARRAY OF SIX (6) VALUES DEFINING DISPERSION CURVES   CDM07360
C                    (AS DEFINED BY KLOW) TO BE USED FOR THE SIX        CDM07370
C                    STABILITY CATEGORIES SUMMARIZED IN THE JOINT       CDM07380
C                    FREQUENCY FUNCTION.                                CDM07390
      IF (((KLOW .GE. 1).AND.(KLOW .LE. 7)).OR.(NDEF .GT. 0)) GO TO 80 CDM07400
      WRITE(IWR,70) KLOW                                                CDM07410
   70 FORMAT('0*** VALID VALUES FOR KLOW RANGE FROM 1 TO 7.',/          CDM07420
     *        ' *** USER INPUT KLOW =',I4)                              CDM07430
      ICOND = 1                                                         CDM07440
   80 DO 100 I = 1,6                                                    CDM07450
         IF (((ICA(I).GE.1).AND.(ICA(I).LE.7)).OR.(NDEF.GT.0)) GO TO 10CDM07460
         WRITE(IWR,90) I,ICA(I)                                         CDM07470
   90    FORMAT('0*** VALID VALUES FOR ICA RANGE FROM 1 TO 7.',/        CDM07480
     *           ' *** USER INPUT ICA(',I1,') =',I4)                    CDM07490
         ICOND = 1                                                      CDM07500
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  100 CONTINUE                                                          CDM07510
C                                                                       CDM07520
C          READ RECORD TYPE 6                                           CDM07530
C                                                                       CDM07540
      READ(IRD,*) KHIGH,ICP                                             CDM07550
C          KHIGH:  DISPERSION PARAMETER SCHEME FOR POINT SOURCES        CDM07560
C          ICP:    ARRAY OF SIX (6) VALUES DEFINING THE DISPERSION CURVECDM07570
C                    (AS DEFINED BY KHIGH) TO BE USED FOR THE SIX       CDM07580
C                    STABILITY CATEGORIES SUMMARIZED IN THE JOINT       CDM07590
C                    FREQUENCY FUNCTION.                                CDM07600
      IF (((KHIGH.GE.1).AND.(KHIGH.LE.7)).OR.(NDEF.GT.0)) GO TO 120     CDM07610
      WRITE(IWR,110) KHIGH                                              CDM07620
  110 FORMAT('0*** VALID VALUES FOR KHIGH RANGE FROM 1 TO 7.',/         CDM07630
     *       ' *** USER INPUT KHIGH =',I4)                              CDM07640
      ICOND = 1                                                         CDM07650
  120 DO 140 I = 1,6                                                    CDM07660
         IF (((ICP(I).GE.1).AND.(ICP(I).LE.7)).OR.(NDEF.GT.0)) GO TO 14CDM07670
         WRITE(IWR,130) I,ICP(I)                                        CDM07680
  130    FORMAT('0*** VALID VALUES FOR ICP RANGE FROM 1 TO 7.',/        CDM07690
     *          ' *** USER INPUT ICP(',I1,') =',I4)                     CDM07700
         ICOND = 1                                                      CDM07710
  140 CONTINUE                                                          CDM07720
      IF (ICOND .NE. 0) GO TO 810                                       CDM07730
C                                                                       CDM07740
C          INITIALIZE ARRAY SOURCE AND WIND DIRECTION ARRAYS            CDM07750
C                                                                       CDM07760
      DO 150 I=1,NASE                                                   CDM07770
         DO 150 J=1,NASN                                                CDM07780
C                EFFECTIVE STACK HEIGHT MUST BE GE 1.                   CDM07790
            Z(I,J,3)=1.                                                 CDM07800
            DO 150 K=1,2                                                CDM07810
               Z(I,J,K)=0.                                              CDM07820
  150 CONTINUE                                                          CDM07830
      TK(1)=0.                                                          CDM07840
      DELTA = 22.5                                                      CDM07850
      IF(N1636.EQ.36) DELTA = 10.0                                      CDM07860
      RDELTA = DELTA/RAD                                                CDM07870
      TTAN = TAN(RDELTA/2.0)                                            CDM07880
      DO 160 I=2,N1636                                                  CDM07890
         TK(I)=TK(I-1)+DELTA                                            CDM07900
  160 CONTINUE                                                          CDM07910
C                                                                       CDM07920
C          READ RECORD TYPE 7                                           CDM07930
C                                                                       CDM07940
      READ(IRD,170)DELR,RAT,CV,XG,YG,TOA,TXX                            CDM07950
C          DELR:   RADIAL INCREMENT (M)                                 CDM07960
C          RAT:    WIDTH OF A BASIC EMISSION GRID SQUARE (USER UNITS)   CDM07970
C          CV:     CONVERSION FACTOR, CV*RAT = EMISSION GRID INTERVAL (M)CDM07980
C          XG:     X MAP COORD. OF THE SW CORNER OF THE EMISSION GRID   CDM07990
C                    ARRAY                                              CDM08000
C          YG:     Y MAP COORD. OF THE SW CORNER OF THE EMISSION GRID   CDM08010
C                    ARRAY                                              CDM08020
C          TOA:    MEAN ATMOSPHERIC TEMPERATURE (DEG C)                 CDM08030
C          TXX:    WIDTH OF BASIC EMISSION GRID SQUARE (M)              CDM08040
  170 FORMAT(12F6.0)                                                    CDM08050
      IF (TXX .EQ. 0) GO TO 175                                         CDM08060
      CHK = ABS(1.0 - (RAT*CV/TXX))                                     CDM08070
      IF (CHK .LE. 0.01) GO TO 185                                      CDM08080
  175 WRITE(IWR,180)                                                    CDM08090
  180 FORMAT('0*** THE PRODUCT OF RAT AND CV MUST EQUAL TXX.',/         CDM08100
     *       ' *** THE VALUES PROVIDED BY THE USER DO NOT CONFORM TO ',CDM08110
     *         'THIS RELATIONSHIP.')                                    CDM08120
      ICOND = 1                                                         CDM08130
      GO TO 810                                                         CDM08140
C                                                                       CDM08150
C          COMPUTE MAXIMUM LENGTH (M) OF SIDE OF EMISSION               CDM08160
C           GRID SQUARE MATRIX ( THE 'Z ARRAY')                         CDM08170
C                                                                       CDM08180
  185 TXXTE = NASE*TXX                                                  CDM08190
      TXXTN = NASN*TXX                                                  CDM08200
C                                                                       CDM08210
C          READ RECORD TYPE 8                                           CDM08220
C                                                                       CDM08230
      READ(IRD,170)DINT,YD,YN,SZA,GB                                    CDM08240
C          DINT:   NUMBER OF SEGMENTS DESIRED IN DELTA DEGREE SECTORS.  CDM08250
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C                   RANGES FROM 2 TO 20 INCLUSIVE.                      CDM08260
C         YD:     RATIO OF THE DAYTIME EMISSION RATE TO THE AVERAGE     CDM08270
C                   24-HOUR EMISSION RATE                               CDM08280
C         YN:     RATIO OF THE NIGHTTIME EMISSION RATE TO THE AVERAGE   CDM08290
C                   24-HOUR EMISSION RATE                               CDM08300
C         SZA(N): INITIAL SIGMA-Z FOR AREA SOURCES (M)                  CDM08310
C                   N = STABILITY CLASS                                 CDM08320
C         GB(N):  DECAY HALF-LIFE (HR) FOR THE TWO POLLUTANTS           CDM08330
C                   N = POLLUTANT NUMBER                                CDM08340
      IF ((DINT.GE.2.).AND.(DINT.LE.20.)) GO TO 200                     CDM08350
      WRITE(IWR,190) DINT                                               CDM08360
  190 FORMAT('0*** VALID VALUES FOR DINT RANGE FROM 2 TO 20.',/         CDM08370
     *       ' *** USER INPUT DINT = ',F5.1)                            CDM08380
      ICOND = 1                                                         CDM08390
      GO TO 810                                                         CDM08400
C                                                                       CDM08410
C         READ RECORD TYPE 9                                            CDM08420
C                                                                       CDM08430
  200 READ(IRD,*) (UE(I),I=1,6)                                         CDM08440
C         UE(I):  ARRAY OF SIX (6) VALUES DEFINING WIND PROFILE         CDM08450
C                   EXPONENTS TO BE ASSOCIATED WITH THE SIX STABILITY   CDM08460
C                   CATEGORIES SUMMARIZED IN THE JOINT FREQUENCY        CDM08470
C                   FUNCTION.  I = STABILITY CLASS                      CDM08480
C                                                                       CDM08490
C         READ RECORD TYPE 10                                           CDM08500
C                                                                       CDM08510
      READ(IRD,*) (U(I),I=1,6)                                          CDM08520
C         U(I):   ARRAY OF SIX (6) VALUES DEFINING WIND SPEEDS (M/SEC)  CDM08530
C                   TO BE ASSOCIATED WITH THE SIX WIND SPEED CATEGORIESCDM08540
C                   SUMMARIZED IN THE JOINT FREQUENCY FUNCTION.         CDM08550
C                   TYPICALLY THE HARMONIC AVERAGE WIND SPEED IS USED.  CDM08560
C                                                                       CDM08570
C         READ RECORD TYPE 11                                           CDM08580
C                                                                       CDM08590
      READ(IRD,*) (HL(I),I=1,6)                                         CDM08600
C         HL(I):   ARRAY OF SIX (6) VALUES DEFINING MIXING HEIGHTS (M)  CDM08610
C                   TO BE ASSOCIATED WITH THE SIX STABILITY CATEGORIES  CDM08620
C                   SUMMARIZED IN THE JOINT FREQUENCY FUNCTION.         CDM08630
C                   I = STABILITY CLASS                                 CDM08640
C                                                                       CDM08650
C         READ RECORD TYPE 12                                           CDM08660
C                                                                       CDM08670
      READ(IRD,210) FMETEO                                              CDM08680
  210 FORMAT(16A4)                                                      CDM08690
C                                                                       CDM08700
C         READ RECORD TYPE 13                                           CDM08710
C                                                                       CDM08720
      DO 220 I=1,6                                                      CDM08730
         DO 220 K=1,N1636                                               CDM08740
            READ(IRD,FMETEO)(F(I,J,K),J=1,6)                            CDM08750
C               F(I,J,K): JOINT FREQUENCY FUNCTION...                   CDM08760
C                         I = STABILITY CLASS                           CDM08770
C                         J = WIND SPEED CLASS                          CDM08780
C                         K = WIND DIRECTION                            CDM08790
            DO 220 JJ=1,6                                               CDM08800
               UBAR(I) = UBAR(I) + U(JJ)*F(I,JJ,K)                      CDM08810
               DUM(I) = DUM(I) + F(I,JJ,K)                              CDM08820
  220 CONTINUE                                                          CDM08830
C                                                                       CDM08840
C         IF NDEF > 0, THEN SET DEFAULT VALUES.                         CDM08850
C                                                                       CDM08860
       IF (NDEF.GT.0) CALL DFAULT(NSO2,CA,CB,NP50,NPDH,NSTDW,NGRAD,KLOW,CDM08870
     *                            ICA,KHIGH,ICP,SZA,GB,UE)              CDM08880
C                                                                       CDM08890
C         COMPUTE AVERAGE WIND SPEED FOR EACH DIRECTION SECTOR          CDM08900
C                                                                       CDM08910
      DO 240 II=1,6                                                     CDM08920
         IF(DUM(II).NE.0.) GO TO 230                                    CDM08930
            UBAR(II)=0.                                                 CDM08940
         GO TO 240                                                      CDM08950
  230       UBAR(II) = UBAR(II)/DUM(II)                                 CDM08960
  240 CONTINUE                                                          CDM08970
C                                                                       CDM08980
C         DEFINE AMBIENT TEMPERATURE, SECTOR INTEGRATION PARAMETERS,    CDM08990
C          AND POLLUTANT HALF-LIFE.                                     CDM09000
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C
      TOA=TOA+273.16
      DR=DELR/(CV*RAT)
      KTC=DINT+1.
      THETA=DELTA/DINT
      TANG = 90.0 - DELTA/2.0
      DO 250 I=1,N1636
         B=TK(I)/RAD
         WB(I)=SIN(B)
         WA(I)=COS(B)
         DO 250 J=1,KTC
            X=TANG-TK(I)+(J-1)*THETA
            IF(X.LT.0.) X=X+360.
            TT(I,J)=X/RAD
  250 CONTINUE
C          DEFINE HALF LIFE FOR P 1 AND  P 2
      GA(1)=GB(1)*3600./0.693
      GA(2)=GB(2)*3600./0.693
C
C          DEFINE INITIAL SIGMAS
C
      DO 270 JA=1,6
         JB=ICA(JA)
         WHA(JA) = FAC + (5.0/U(JA))*(1.0-FAC)
         HX(JA)=0.8*HL(JA)
         SA=SZA(JA)
         IF(SA.GT.0.) GO TO 260
         S=0.
         GO TO 270
  260    CALL VIRTX(KLOW,NPDH,JB,0.0,SA,S)
  270    XS(JA)=S
C
C          EVALUATE PRINTER CONTROL OPTION
C
      IF(NLIST.LT.0) GO TO 610
C
C          ECHO SETUP INFORMATION AND METEOROLOGICAL INPUT
C
      WRITE(IWR,280)IVER,IRUN,HEADNG
  280 FORMAT('1',35X,'CLIMATOLOGICAL DISPERSION MODEL - VERSION 2.0',/
     *        1X,48X,'CODE VERSION ',I5,/
     *        1X,53X,'RUN ',I5,//,
     *        1X,20A4,/)
      WRITE(IWR,290)N1636
  290 FORMAT(1X,'TECHNICAL OPTIONS:',/
     *      1X,'     NUMBER OF WIND DIRECTIONS USED IN METEOROLOGICAL '
     *          'JOINT',/,
     *      1X,'      FREQUENCY FUNCTION (N1636) ',30('.'),I5)
      WRITE(IWR,300)KLOW,(DISP(I,KLOW), I = 1,8),
     *              KHIGH,(DISP(I,KHIGH), I = 1,8)
  300 FORMAT(1X,'     DISPERSION PARAMETER SCHEME FOR AREA SOURCES ',
     *          '(KLOW) ',7('.'),I5,12X,8A4/
     *      1X,'     DISPERSION PARAMETER SCHEME FOR POINT SOURCES ',
     *          '(KHIGH) ',5('.'),I5,12X,8A4)
      WRITE(IWR,310)FAC
  310 FORMAT(1X,'     EFFLUENT RISE FOR AREA SOURCES (FAC) ',22('.'),
     *          4X,1PE12.6)
      WRITE(IWR,320) RCEPTZ
  320 FORMAT(1X,'     HEIGHT ABOVE GROUND OF ALL RECEPTORS (RCEPTZ) ',
     *          13('.'),4X,1PE12.6,' M')
      WRITE(IWR,330) PNAME(1),CA(1),CB(1)
      WRITE(IWR,330) PNAME(2),CA(2),CB(2)
  330 FORMAT(1X,'     CALIBRATION CONSTANTS -- ',A4,/,
     *      1X,8X,'INTERCEPT OF CALIBRATION ',30('.'),4X,1PE12.6,
     *          ' MICROGRAMS/CU. METER',/
     *      1X,8X,'SLOPE OF CALIBRATION ',34('.'),4X,1PE12.6,
     *          ' DIMENSIONLESS')
      WRITE(IWR,340)NP50,NPDH,NSTDW,NGRAD,NDEF
  340 FORMAT(1X,'     INITIAL DISPERSION OPTION (NP50) ',26('.'),I5,/,
     *      1X,'     BUOYANCY INDUCED DISPERSION OPTION (NPDH) ',
     *          17('.'),3X,I2,/
     *      1X,'     STACK DOWNWASH OPTION (NSTDW) ',29('.'),3X,I2,/,
     *      1X,'     GRADUAL PLUME RISE OPTION (NGRAD) ',25('.'),3X,I2,
     *      1X,'     DEFAULT OPTION (NDEF) ',37('.'),3X,I2,/)
      WRITE(IWR,360) NLIST
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360 FORMAT('0PRINT OPTIONS:',/
   *        1X,'    CONTROL FOR PRINTED OUTPUT ',32('.'),I5)
    WRITE(IWR,370) IRD,IWR,IPU
370 FORMAT(1X,'    FORTRAN LOGICAL UNIT NUMBER (READ) ',24('.'),I5/
   *  1X,'    FORTRAN LOGICAL UNIT NUMBER (PRINTER) ',21('.'),I5/
   *  1X,'    FORTRAN LOGICAL UNIT NUMBER (PUNCH) ',23('.'),I5/)
    WRITE(IWR,380)XG
380 FORMAT(1X,'OPERATING PARAMETERS:',/
   *        1X,'    X-MINIMUM OF AREA EMISSION INVENTORY MAP GRID',
   *            ' (XG) ',8('.'),4X,1PE12.6,' USER UNITS')
    WRITE(IWR,390)YG,RAT
390 FORMAT(1X,'    Y-MINIMUM OF AREA EMISSION INVENTORY MAP GRID',
   *            ' (YG) ',8('.'),4X,1PE12.6,' USER UNITS',/
   *        1X,'    WIDTH OF A BASIC EMISSION GRID SQUARE (RAT) ',
   *            15('.'),4X,1PE12.6,' USER UNITS')
    WRITE(IWR,400)CV,TXX
400 FORMAT(1X,'    GRID CONVERSION FACTOR (CV) ',31('.'),
   *            4X,1PE12.6,' M/USER UNITS'/,
   *        1X,'    WIDTH OF A BASIC EMISSION GRID SQUARE (TXX) ',
   *            15('.'),4X,1PE12.6,' M')
    WRITE(IWR,410)DINT
410 FORMAT(1X,'    NUMBER OF SUBSECTORS CONSIDERED FOR EACH SECT',
   *            'OR (DINT) ',4('.'),4X,1PE12.6,' DIMENSIONLESS')
    WRITE(IWR,420)THETA,DELR
420 FORMAT(1X,'    ANGULAR WIDTH OF A SUBSECTOR (THETA) ',22('.'),
   *            4X,1PE12.6,' DEG',/
   *        1X,'    INITIAL RADIAL INCREMENT (DELR) ',27('.'),
   *            4X,1PE12.6,' M'/)
    WRITE(IWR,430)TOA
430 FORMAT(1X,'MISCELLANEOUS METEOROLOGICAL DATA:',/
   *        1X,'    AMBIENT AIR TEMPERATURE (TOA) ',29('.'),
   *            4X,1PE12.6,' K')
    WRITE(IWR,440)(I,HL(I),I=1,6)
440 FORMAT(1X,'    MIXING HEIGHTS BY STABILITY CLASS (HL):',/
   *        '           STABILITY CLASS:',I6,1X,33('.'),4X,1PE12.6,' M',/
   *        5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M',/))
    WRITE(IWR,280)IVER,IRUN,HEADNG
    WRITE(IWR,450)
450 FORMAT(1X,'MISCELLANEOUS METEOROLOGICAL DATA (CONTINUED):',//,
   *        1X,'    CENTRAL WIND SPEED OF THE SIX WIND SPEED CLAS',
   *            'SES (U):')
    WRITE(IWR,460)(I,U(I),I=1,6)
460 FORMAT(1X,'          WIND SPEED CLASS:  ',I2,1X,33('.'),
   *            4X,1PE12.6,' M/SEC',/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M/SEC',/))
    WRITE(IWR,470)(I,UE(I),T=1,6)
470 FORMAT(1X,'    EXPONENTIAL OF THE VERTICAL WIND PROFILE (UE):'/
   *        1X,'          STABILITY CLASS:   ',I2,1X,33('.'),
   *            4X,1PE12.6,' DIMENSIONLESS'/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' DIMENSIONLESS'/)//)
    WRITE(IWR,480)PNAME(1),PNAME(2)
480 FORMAT(1X,'SOURCE DATA:',//,
   *        1X,'    POLLUTANTS TO BE MODELFD ',34('.'),4X,A4,' & ',A4)
    WRITE(IWR,490)PNAME(1),GB(1),PNAME(2),GB(2)
490 FORMAT(1X,'    DECAY HALF-LIFE FOR ',A4,' (GB(1)) ',26('.'),
   *            4X,1PE12.6,' HR',/
   *        1X,'    DECAY HALF-LIFE FOR ',A4,' (GB(2)) ',26('.'),
   *            4X,1PE12.6,' HR')
    WRITE(IWR,500)YD,YN
500 FORMAT(1X,'    DAYTIME EMISSION WEIGHT FACTOR (YD) ',23('.'),
   *            4X,1PE12.6,' DIMENSIONLESS'/
   *        1X,'    NIGHTTIME EMISSION WEIGHT FACTOR (YN) '21('.'),
   *            4X,1PE12.6,' DIMENSIONLESS')
    WRITE(IWR,510)
510 FORMAT(1X,'    INITIAL SIGMA-Z FOR AREA SOURCES (SZA):')
    WRITE(IWR,520)(I,SZA(I),I=1,6)
520 FORMAT(1X,'          STABILITY CLASS:   ',I2,1X,33('.'),
   *            4X,1PE12.6,' M',/
   *      5(1X,27X,I2,1X,33('.'),4X,1PE12.6,' M',/))
    DO 530 I = 1,6
       IDUM = ICP(I)
       JDUM = ICA(I)
       PCURVE(I) = CURVE(IDUM)
       ACURVE(I) = CURVE(JDUM)
530 CONTINUE
```

```
      WRITE(IWR,540) (I,PCURVE(I),ACURVE(I), I = 1,6)                   CDM10510
  540 FORMAT(1X,'DISPERSION CURVE USED FOR EACH STABILTY CLASS',/,      CDM10520
     *           4X,'STABILITY          POINT            AREA',/,       CDM10530
     *           4X,'  CLASS            SOURCES          SOURCES',/,    CDM10540
     *     6(7X,I2,12X,A4,11X,A4,/))                                    CDM10550
      DO 610 I=1,6                                                      CDM10560
         IF((N1636.EQ.16) .AND. ((I/2)*2.EQ.I)) GO TO 560               CDM10570
         WRITE(IWR,280)IVER,IRUN,HEADNG                                 CDM10580
         WRITE(IWR,550)                                                 CDM10590
  550    FORMAT(1X,38X,'METEOROLOGICAL JOINT FREQUENCY FUNCTION',//)    CDM10600
  560    WRITE(IWR,570)I                                                CDM10610
  570    FORMAT(1X,'STABILITY CLASS',I2,47X,'WIND SPEED CLASS',//       CDM10620
     *          1X,4X,'WIND DIRECTION    SECTOR',                       CDM10630
     *          11X,'1',12X,'2',12X,'3',12X,'4',12X,'5',12X,'6',/)      CDM10640
         DO 590 K=1,N1636                                               CDM10650
            IF(N1636 .EQ. 36)                                           CDM10660
     *         WRITE(IWR,580)D36(2*K-1),D36(2*K),K,(F(I,J,K),J=1,6)     CDM10670
            IF(N1636 .EQ. 16)                                           CDM10680
     *         WRITE(IWR,580)D16(2*K-1),D16(2*K),K,(F(I,J,K),J=1,6)     CDM10690
  580          FORMAT(1X,7X,2A4,9X,I2,9X,6(F8.6,5X))                    CDM10700
  590    CONTINUE                                                       CDM10710
         WRITE(IWR,600)UBAR(I)                                          CDM10720
  600    FORMAT(/,1X,55X,'COMPUTED MEAN SPEED = ',F5.2,' M/SEC',2(/))   CDM10730
  610 CONTINUE                                                          CDM10740
C                                                                       CDM10750
C         READ RECORD TYPE 14                                           CDM10760
C                                                                       CDM10770
      READ(IRD,210) FSOURC                                              CDM10780
      CON1 = FLOAT(N1636)/(2.0*3.14159)                                 CDM10790
      CON2 = CON1*PI                                                    CDM10800
C                                                                       CDM10810
C         READ SOURCE INPUT DATA (I.E., RECORD TYPE 15)                 CDM10820
C                                                                       CDM10830
  620 READ(IRD,FSOURC)X,Y,TX,S1,S2,SH,D,VS,T,SA                         CDM10840
C         X:   X MAP COORDINATE OF SOURCE                               CDM10850
C         Y:   Y MAP COORDINATE OF SOURCE                               CDM10860
C         TX:  WIDTH OF AREA SOURCES                                    CDM10870
C         S1:  EMISSION RATE OF POLLUTANT 1 (G/SEC)                     CDM10880
C         S2:  EMISSION RATE OF POLLUTANT 2 (G/SEC)                     CDM10890
C         SH:  SOURCE HEIGHT (M)                                        CDM10900
C         D:   STACK DIAMETER (M)                                       CDM10910
C         VS:  EXIT VELOCITY (M/S)                                      CDM10920
C         T:   STACK GAS TEMPERATURE (DEG F, C, OR K)                   CDM10930
C         SA:  PLUME RISE OPTION                                        CDM10940
      IF (NDEF .GT. 0) SA = 0.0                                         CDM10950
      XSS = X                                                           CDM10960
      YSS = Y                                                           CDM10970
C                                                                       CDM10980
C         TEST END OF SOURCE DATA (BLANK CARD)                          CDM10990
C                                                                       CDM11000
      IF(S1+S2.LE.0.) GO TO 790                                         CDM11010
C                                                                       CDM11020
C         EVALUATE PRINTER CONTROL OPTION                               CDM11030
C                                                                       CDM11040
      IF(NLIST.NE.0) GO TO 680                                          CDM11050
C                                                                       CDM11060
C         ECHO SOURCE INPUT DATA                                        CDM11070
C                                                                       CDM11080
      IF(IPG.LT.44) GO TO 660                                           CDM11090
      IPG=0                                                             CDM11100
      WRITE(IWR,280)IVER,IRUN,HEADNG                                    CDM11110
      WRITE(IWR,630)                                                    CDM11120
  630 FORMAT(1X,42X,'AREA AND POINT SOURCE INVENTORY',//,               CDM11130
     *         1X,84X,'STACK     STACK       OPTIONAL',/,               CDM11140
     *         1X,27X,'WIDTH OF      ----EMISSION RATE----    SOURCE    ',CDM11150
     *         'STACK     EXIT        GAS        PLUME RISE')           CDM11160
      WRITE(IWR,640)PNAME(1),PNAME(2)                                   CDM11170
  640 FORMAT(1X,'  X MAP          Y MAP       GRID SQUARE',5X,A4,9X,A4,6X,CDM11180
     *         'HEIGHT     DIAM      SPEED      TEMP      COEFFICIENT')  CDM11190
      I = 1                                                             CDM11200
      IF (KELVIN .EQ. 0) I = 2                                          CDM11210
      IF (KELVIN .GT. 0) I = 3                                          CDM11220
      WRITE(IWR,650) TTITLE(I)                                          CDM11230
  650 FORMAT(1X,'COORDINATE   COORDINATE        (M)          (G/SEC)',  CDM11240
     *         '       (G/SEC)       (M)        (M)     (M/SEC)   (DEG',A4,  CDM11250
     *        '   (M**2/SEC)',/)
  660 IPG=IPG+1
      WRITE(IWR,670)X,Y,TX,S1,S2,SH,D,VS,T,SA
  670 FORMAT(1X,1X,F7.2,6X,F7.2,7X,F6.0,6X,F8.2,5X,F8.2,4X,F6.2,
     *       4X,F5.2,4X,F5.2,5X,F5.1,7X,F6.2)
C          EFFECTIVE STACK HEIGHT MUST BE GE 1.
  680 IF(SH.LT.1.) SH=1.
C
C          IF POINT SOURCE THEN GO TO 750
C
      IF(TX.LE.0.) GO TO 750
C
C          SOURCE IS AREA TYPE.  MODIFY SOURCE COORDINATES, DIMENSIONS,
C           AND EMISSION RATE TO CONFORM TO CDM-2.0 REQUIREMENTS.
C
      D=TX*0.5/CV
      X=X+D
      Y=Y+D
      W=TX/TXX
      S=TX*TX
      B=S1/S
      D=S2/S
C          BECAUSE OF THE METHOD OF INTEGRATION, AREA SOURCES ARE
C           DIVIDED BY TWO AT THIS POINT FOR MORE EFFICIENT EXECUTION
C           OF SUBROUTINE AREA.
      B=B*0.5
      D=D*0.5
      X=(X-XG)/RAT+1.
      Y=(Y-YG)/RAT+1.
      IF(W.GT.1.) GO TO 690
      M=X
      N=Y
      K=M
      L=N
      GO TO 700
  690 S=W*0.5
      K=(X-S)+0.55
      L=(Y-S)+0.55
      M=(K+W)-0.45
      N=(L+W)-0.45
  700 CONTINUE
C
C          IF SOURCE DIMENSIONS ARE OUTSIDE CDM-2.0 LIMITS THEN PRINT
C           ERROR MESSAGE AND READ NEXT SOURCE
C
      IF (M.GT.NASE.OR.N.GT.NASN) GO TO 710
      IF (M.LE.0.OR.N.LE.0) GO TO 710
      IF (L.GT.NASN.OR.K.GT.NASE) GO TO 710
      IF (L.LE.0.OR.K.LE.0) GO TO 710
      IF (M.LT.K) GO TO 710
      IF (N.LT.L) GO TO 710
      GO TO 730
C          PRINT ERROR MESSAGE FOR THIS AREA SOURCE
  710 WRITE(IWR,720) XSS,YSS,TXXTE,TXXTN
  720 FORMAT('0',7X,'NOTE:  AREA SOURCE WITH X COORD ',F10.2,
     *  ' AND Y COORD ',F10.2,', VIOLATES',/,15X,
     *  'AREA SOURCE ARRAY LIMITS.  AREA SOURCES MUST LIE ENTIRELY ',
     *  'WITHIN A ',F11.2,' BY ',F11.2,/,15X,
     *  'METER SQUARE WITH SOUTHWEST CORNER AT THE USER-DEFINED ',
     *  'ORIGIN (XG,YG).  THIS',/,15X,
     *  'SOURCE  WILL NOT BE INCLUDED IN THIS CALCULATION.',/)
      GO TO 620
C
C          STORE AREA SOURCE INFORMATION
C
  730 DO 740 I=K,M
         DO 740 J=L,N
            Z(I,J,1)=B
            Z(I,J,2)=D
  740       Z(I,J,3)=SH
      IF(M.GT.IXX) IXX=M
      IF(N.GT.IYY) IYY=N
C
C          INCREMENT AREA SOURCE COUNTER
C
```

```
      IAS=IAS+1
C
C         GO BACK AND READ NEXT SOURCE
C
      GO TO 620
C
C         INCREMENT POINT SOURCE COUNTER
C
  750 IPS=IPS+1
C
C         STORE POINT SOURCE INFORMATION
C
      PX(IPS)=(X-XG)/RAT+0.5
      PY(IPS)=(Y-YG)/RAT+0.5
      PS(IPS,1)=S1*CON2
      PS(IPS,2)=S2*CON2
      PS(IPS,3)=S1*CON1
      PS(IPS,4)=S2*CON1
      PH(IPS)=SH
      PR(IPS)=SA
      IF(KELVIN.GE.0) GO TO 755
      T=(T-32.0)*(5./9.)+273.16
      GO TO 760
  755 IF(KELVIN.GT.0) GO TO 760
      T=T+273.16
  760 IF(D .LE. 0.) D = 0.01
      VS1(IPS)=VS
      T1(IPS) = T
      D1(IPS) = D
      FRN(IPS)=VS*VS*TOA/(9.80616*D*(T-TOA))
      BFLUX(IPS) = (9.80616 * VS * D * D * (T - TOA))/(4. * T)
C
C         GO BACK AND READ NEXT SOURCE
C
      GO TO 620
C
C         PREPARE TO RETURN TO MAIN
C
  790 IPG=70
C
C         COMPUTE NE CORNER OF NE GRID SQUARE
C
      TDA=0.5-TD
      TDB=IXX+0.5+TD
      TDC=IYY+0.5+TD
C
C         PRINT NUMBER OF POINT AND AREA SOURCES
C
      WRITE(IWR,800)IAS,IPS
  800 FORMAT('0',I10,' AREA SOURCES.',I10,' POINT SOURCES.')
  810 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE DFAULT(NSO2,CA,CB,NP50,NPDH,NSTDW,NGRAD,KLOW,ICA,KHIGH
     *                  ICP,SZA,GB,UE)
C           SUBROUTINE DFAULT   (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:   NSO2  - POLLUTANT NUMBER FOR SO2
C         OUTPUT:  CA    - INTERCEPT OF CALIBRATION
C                  CB    - SLOPE OF CALIBRATION
C                  NP50  - INITIAL DISPERSION OPTION
C                  NPDH  - BUOYANCY-INDUCED DISPERSION OPTION
C                  NSTDW - STACK DOWNWASH OPTION
C                  NGRAD - GRADUAL PLUME RISE OPTION
C                  KLOW  - DISPERSION PARAMETER SCHEME FOR AREA SOURCES
C                  ICA   - ARRAY OF SIX VALUES DEFINING DISPERSION
C                          CURVES (AS DEFINED BY KLOW) TO BE USED FOR
C                          THE SIX STABILITY CATEGORIES SUMMARIZED IN
C                          THE JOINT FREQUENCY FUNCTION
C                  KHIGH - DISPERSION PARAMETER SCHEME FOR POINT SOURCE
C                  ICP   - ARRAY OF SIX VALUES DEFINING DISPERSION
C                          CURVES (AS DEFINED BY KHIGH) TO BE USED FOR
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C                            THE SIX STABILITY CATEGORIES SUMMARIZED IN CDM12760
C                            THE JOINT FREQUENCY FUNCTION               CDM12770
C                   SZA   - INITIAL SIGMA-Z FOR AREA SOURCES (METERS)   CDM12780
C                   GB    - DECAY HALF-LIFE (HRS) FOR THE TWO POLLUTANTSCDM12790
C                   UE    - ARRAY OF SIX VALUES DEFINING WIND PROFILE   CDM12800
C                            EXPONENTS TO BE ASSOCIATED WITH THE SIX    CDM12810
C                            STABILITY CATEGORIES SUMMARIZED IN THE     CDM12820
C                            JOINT FREQUENCY FUNCTION.                  CDM12830
C                                                                       CDM12840
C       CALLING ROUTINE:                                                CDM12850
C         CLINT                                                         CDM12860
C                                                                       CDM12870
C       DESCRIPTION:                                                    CDM12880
C         THIS SUBROUTINE SETS PARAMETERS ACCORDING TO REGULATORY       CDM12890
C         GUIDANCE ESTABLISHED IN "GUIDELINE ON AIR QUALITY MODELS."    CDM12900
C         THIS MODULE WAS ADDED TO THE CODE AS A CONVENIENCE FOR THE    CDM12910
C         USER TO HELP AVOID INADVERTANT ERRORS IN SETTING THE          CDM12920
C         APPROPRIATE OPTIONS FOR REGULATORY USES.                      CDM12930
C                                                                       CDM12940
      DIMENSION CA(2),CB(2),ICA(6),ICP(6),SZA(6),GB(2),UE(6)            CDM12950
C                                                                       CDM12960
C         SET CALIBRATION CONSTANTS                                     CDM12970
C                                                                       CDM12980
      DO 10 I = 1,2                                                     CDM12990
         CA(I) = 0.0                                                    CDM13000
         CB(I) = 1.0                                                    CDM13010
   10 CONTINUE                                                          CDM13020
C                                                                       CDM13030
C         SET PROGRAM CONTROL PARAMETERS                                CDM13040
C                                                                       CDM13050
      NP50  = 0                                                         CDM13060
      NPDH  = 1                                                         CDM13070
      NSTDW = 1                                                         CDM13080
      NGRAD = 0                                                         CDM13090
C                                                                       CDM13100
C         SET DISPERSION SCHEME, DISPERSION CURVES, AND INITIAL SIGMAS  CDM13110
C                                                                       CDM13120
      KLOW  = 2                                                         CDM13130
      KHIGH = 2                                                         CDM13140
      DO 20 I = 1,6                                                     CDM13150
         ICA(I) = I                                                     CDM13160
         ICP(I) = I                                                     CDM13170
         SZA(I) = 30.                                                   CDM13180
   20 CONTINUE                                                          CDM13190
C                                                                       CDM13200
C         SET WIND PROFILE EXPONENTS                                    CDM13210
C                                                                       CDM13220
      UE(1) = .15                                                       CDM13230
      UE(2) = .15                                                       CDM13240
      UE(3) = .20                                                       CDM13250
      UE(4) = .25                                                       CDM13260
      UE(5) = .25                                                       CDM13270
      UE(6) = .30                                                       CDM13280
C                                                                       CDM13290
C         SET POLLUTANT HALF-LIFE                                       CDM13300
C                                                                       CDM13310
      IF ((NSO2 .EQ. 1) .OR. (NSO2 .EQ. 2)) GO TO 30                    CDM13320
         GB(1) = 999999.                                                CDM13330
         GB(2) = 999999.                                                CDM13340
         GO TO 999                                                      CDM13350
   30 CONTINUE                                                          CDM13360
      IF (NSO2 .EQ. 2) GO TO 40                                         CDM13370
         GB(1) = 4.0                                                    CDM13380
         GB(2) = 999999.                                                CDM13390
         GO TO 999                                                      CDM13400
   40 CONTINUE                                                          CDM13410
         GB(1) = 999999.                                                CDM13420
         GB(2) = 4.0                                                    CDM13430
C                                                                       CDM13440
  999 RETURN                                                            CDM13450
      END                                                               CDM13460
C                                                                       CDM13470
C***********************************************************************CDM13480
C                                                                       CDM13490
      SUBROUTINE CALQ                                                   CDM13500
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C              SUBROUTINE CALQ   (VERSION 85293), PART OF CDM-2.0.
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION C(3)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /C6/ ICHK
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,
     *              Z(NASE,NASN,3)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *             PPAR(2,6),APAR(2,6),WHA(6),PAC,RCEPTZ,KELVIN,NDEF
C         CALCULATE SECTOR AREA SOURCE VECTOR Q(NQ,I)
C            N = INDEX OF RADIAL ARC
C            I = 1: P 1 EMISSION RATE
C            I = 2: P 2 EMISSION RATE
C            I = 3: AREA STACK HEIGHT
C
C         INITIALIZE ARC COUNTER
C
      NQ=0
C
C         INCREMENT ARC COUNTER
C
   10 NQ=NQ+1
C
C         IF THE NUMBER OF ARCS EVALUATED IS LESS THAN THE LIMIT SET
C          BY CDM-2.0 (NQLIM) GO TO 30
C
      IF(NQ.LT.NQLIM) GO TO 30
C
C         THE NUMBER OF ARCS EXCEEDS THE LIMIT SET BY CDM-2.0 PRINT ERR
C          MESSAGE AND RETURN TO MAIN
C
      NQ = NQLIM - 1
      IF(ICHK.EQ.1) GO TO 330
      ICHK = 1
      Q(NQ+1,4) = (N-1)*DELR
      XDIS = Q(NQ+1,4)/1000.0
C         PRINT WARNING MESSAGE
      WRITE(IWR,20) NQLIM,XDIS
   20 FORMAT('0',9X,'WARNING:  MORE THAN',I4,'ARCS ARE REQUIRED FOR ',
     * 'CALCULATION OF AREA CONTRIBUTION.',/,20X,'AREA SOURCES BEYOND'
     *  1X,F5.1,'KM ARE NOT INCLUDED IN THIS CALCULATION.')
      GO TO 340
C
C         THE NUMBER OF ARCS IS WITHIN THE LIMITS SET BY CDM-2.0.
C
   30 DO 40 I=1,3
         Q(NQ+1,I) = 0.0
   40    Q(NQ,I)=0.
      Q(NQ,4)=(N-1)*DELR
      R=(N-1)*DR
C         R:   RADIAL UPWIND DISTANCE
      KT=(N-1)*DELR/2500.+1.
C         KT:  CONTROLS INCREMENT TO NEXT ARC
      IF(KT.GT.4) KT=4
      HN=0.
C
C         LOOP OVER SECTOR INTERVAL COUNTER
C          KTC: CONTROLS NUMBER OF POINTS ALONG ARC (DINT+1)
C
      DO 290 LL=1,KTC
      T=TT(K,LL)
      TI=RI+R*COS(T)
      TJ=RJ+R*SIN(T)
C
C         IF RADIAL ARC OUTSIDE OUTSIDE AREA EMISSION GRID GO TO 290
C          DETERMINE WHICH AREA SOURCE THE POINT FALLS ON.  IF ON THE
C          LINE TWO ARE AVERAGED.  IF ON AN INTERSECTION, FOUR ARE
C          AVERAGED.
C
      IF(TI.LT.TDA.OR.TI.GT.TDB) GO TO 290
      IF(TJ.LT.TDA.OR.TJ.GT.TDC) GO TO 290
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```
C
C         DETERMINE WHICH AREA SOURCE THE POINT FALLS ON
C
      I=TI
      J=TJ
      IF(I.LT.1) I=1
      IF(J.LT.1) J=1
      D=TI-I
      IF(ABS(D-0.5).LE.TD) GO TO 50
      IF(D-0.5)90,50,130
   50 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 60
      IF(D-0.5)70,60,80
   60 IA=1
      JA=5
      GO TO 170
   70 IA=2
      JA=3
      GO TO 170
   80 IA=2
      JA=4
      GO TO 170
   90 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 100
      IF(D-0.5)110,100,120
  100 IA=3
      JA=2
      GO TO 170
  110 IA=3
      JA=3
      GO TO 170
  120 IA=3
      JA=4
      GO TO 170
  130 D=TJ-J
      IF(ABS(D-0.5).LE.TD) GO TO 140
      IF(D-0.5)150,140,160
  140 IA=4
      JA=2
      GO TO 170
  150 IA=4
      JA=3
      GO TO 170
  160 IA=4
      JA=4
  170 CN=0.
      IF(I.EQ.IXX) IA=3
      IF(J.EQ.IYY) JA=3
      DO 180 LD=1,3
  180    C(LD)=0.
      DO 200 IR=1,4
         IV=I+IAD(IR,IA)
         JV=J+IAD(IR,JA)
         DO 190 L=1,2
  190       C(L)=C(L)+Z(IV,JV,L)
         IF(Z(IV,JV,3).LE.0.1) GO TO 200
         CN=CN+1.
         C(3)=C(3)+Z(IV,JV,3)
  200 CONTINUE
      C(1)=C(1)/4.
      C(2)=C(2)/4.
      IF(CN.GT.0.5) GO TO 210
      C(3)=1.
      GO TO 220
  210 C(3)=C(3)/CN
  220 IF(R.GT.0.) GO TO 240
      DO 230 LA=1,3
  230    Q(NQ,LA)=C(LA)
      GO TO 320
  240 IF(LL.NE.1.AND.LL.NE.KTC) GO TO 260
C         TRAPEZOIDAL INTEGRATION APPLIED
      DO 250 LB=1,2
  250    C(LB)=C(LB)*0.5
  260 DO 270 LC=1,2
  270    Q(NQ,LC)=Q(NQ,LC)+C(LC)
```

```
      IF(C(1)+C(2).LE.0.) GO TO 290                                     CDM15010
      Q(NQ,3)=Q(NQ,3)+C(3)                                              CDM15020
  280 HN=HN+1.                                                          CDM15030
  290 CONTINUE                                                          CDM15040
C                                                                       CDM15050
C         COMPUTE AVERAGE EMISSION RATE OVER THE ARC                    CDM15060
C                                                                       CDM15070
      DO 300 LD=1,2                                                     CDM15080
  300    Q(NQ,LD)=Q(NQ,LD)/DINT                                         CDM15090
      IF(HN.GT.0.5) GO TO 310                                           CDM15100
      Q(NQ,3)=1.                                                        CDM15110
      GO TO 320                                                         CDM15120
  310 Q(NQ,3)=Q(NQ,3)/HN                                                CDM15130
  320 N=N+INC(KT)                                                       CDM15140
C                                                                       CDM15150
C         IF NEXT ARC IS WITHIN AREA GRID, GO TO 10 AND INCREMENT ARC   CDM15160
C          COUNTER                                                      CDM15170
C                                                                       CDM15180
      IF(N.LE.MX+1) GO TO 10                                            CDM15190
  330 Q(NQ+1,4)=(N-1)*DELR                                              CDM15200
  340 RETURN                                                            CDM15210
      END                                                               CDM15220
C                                                                       CDM15230
C***********************************************************************CDM15240
C                                                                       CDM15250
      SUBROUTINE AREA                                                   CDM15260
C              SUBROUTINE AREA     (VERSION 85293), PART OF CDM-2.0.    CDM15270
C                                                                       CDM15280
C         THIS SUBROUTINE CALCULATES THE SECTOR CONCENTRATION FROM THE CDM15290
C          AREA SOURCE VECTOR (Q).                                      CDM15300
C                                                                       CDM15310
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)                    CDM15320
      DIMENSION C(2)                                                    CDM15330
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR      CDM15340
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD         CDM15350
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG          CDM15360
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR CDM15370
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU         CDM15380
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)                 CDM15390
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,   CDM15400
     *               PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NGREG CDM15410
      Y=YD                                                              CDM15420
C                                                                       CDM15430
C         LOOP OVER STABILITY CLASS                                     CDM15440
C                                                                       CDM15450
      DO 170 IS=1,6                                                     CDM15460
C         IS: CONTROLS STABILITY CLASS                                  CDM15470
      IF(IS.EQ.5) Y=YN                                                  CDM15480
      IC=ICA(IS)                                                        CDM15490
C                                                                       CDM15500
C         LOOP OVER WIND SPEED CLASS                                    CDM15510
C                                                                       CDM15520
      DO 170 IU=1,6                                                     CDM15530
C         IU: CONTOLS WIND SPEED CLASS                                  CDM15540
C          IF FREQUENCY IS ZERO, SKIP                                   CDM15550
      IF(F(IS,IU,K).LE.0.) GO TO 170                                    CDM15560
C                                                                       CDM15570
C         INITIALIZATION                                                CDM15580
C                                                                       CDM15590
      C(1)=0.                                                           CDM15600
      C(2)=0.                                                           CDM15610
      IR=1                                                              CDM15620
      DVLRI=Q(2,4)-Q(1,4)                                               CDM15630
   10 R=Q(IR,4)                                                         CDM15640
      DVLR=DVLRI                                                        CDM15650
      DVLRI=Q(IR+1,4)-R                                                 CDM15660
      QQQ = 0.1*Q(IR,3)*FAC                                             CDM15670
      IF(QQQ.LT.0.1) QQQ = 0.1                                          CDM15680
      PQQQ = UE(IS)                                                     CDM15690
      WZ = QQQ**PQQQ                                                    CDM15700
      WS=U(IU)*WZ                                                       CDM15710
      DO 20 JA=1,2                                                      CDM15720
         DF=WS*GA(JA)                                                   CDM15730
   20    DECAY(JA)=EXP(R/DF)                                            CDM15740
      RXS=R+XS(IS)                                                      CDM15750
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C                                                                       CDM15760
      CALL SIGMAZ(KLOW,NPDH,IC,RXS,0.0,SZ)                              CDM15770
C                                                                       CDM15780
      IF(SZ.LE.0.) GO TO 140                                            CDM15790
C                                                                       CDM15800
C          IF THE VERTICAL DISPERSION PARAMETER IS GREATER THAN OR      CDM15810
C           EQUAL TO 0.8 X MIXING HEIGHT COMPUTE CONCENTRATION USING    CDM15820
C           A BOX MODEL                                                 CDM15830
C                                                                       CDM15840
      IF(SZ.GE.HX(IS)) GO TO 30                                         CDM15850
C                                                                       CDM15860
C          LID HAS NOT BEEN REACHED; COMPUTE CONCENTRATION BY GAUSSIAN  CDM15870
C           FORMULA.                                                    CDM15880
C                                                                       CDM15890
      STK1 = Q(IR,3)*WHA(IU) + RCEPTZ                                   CDM15900
      STK2 = Q(IR,3)*WHA(IU) - RCEPTZ                                   CDM15910
      SB1 = -0.5*STK1*STK1/(SZ*SZ)                                      CDM15920
      SB2 = -0.5*STK2*STK2/(SZ*SZ)                                      CDM15930
      SWW = 0.5*(EXP(SB1) + EXP(SB2))                                   CDM15940
      S = PI*SWW/(SZ*WS)                                                CDM15950
      GO TO 100                                                         CDM15960
C                                                                       CDM15970
C          LID HAS BEEN REACHED; COMPUTE CONCENTRATION USING A BOX MODELCDM15980
C                                                                       CDM15990
   30 IRI=IR                                                            CDM16000
   40 R=Q(IRI,4)                                                        CDM16010
      DVLR=DVLRI                                                        CDM16020
      DVLRI=Q(IRI+1,4)-R                                                CDM16030
      QQQ = 0.1*Q(IRI,3)*FAC                                            CDM16040
      IF(QQQ.LT.0.1) QQQ = 0.1                                          CDM16050
      PQQQ = UE(IS)                                                     CDM16060
      WZ = QQQ**PQQQ                                                    CDM16070
      WS=U(IU)*WZ                                                       CDM16080
      S=1./(WS*HL(IS))                                                  CDM16090
      DO 50 JB=1,2                                                      CDM16100
         DF=WS*GA(JB)                                                   CDM16110
   50    DECAY(JB)=EXP(R/DF)                                            CDM16120
      IF(IRI.EQ.1.OR.IRI.EQ.NQ) GO TO 70                                CDM16130
      DO 60 JC=1,2                                                      CDM16140
   60    C(JC)=C(JC)+(Q(IRI,JC)*S*(DVLR+DVLRI))/DECAY(JC)               CDM16150
      GO TO 90                                                          CDM16160
C          TRAPEZOIDAL INTEGRATION APPLIED                              CDM16170
   70 DO 80 JF=1,2                                                      CDM16180
   80    C(JF)=C(JF)+(Q(IRI,JF)*S*DVLR)/DECAY(JF)                       CDM16190
   90 IRI=IRI+1                                                         CDM16200
C          LOOPS TO RHO(MAX)                                            CDM16210
      IF(IRI.LE.NQ) GO TO 40                                            CDM16220
      GO TO 150                                                         CDM16230
  100 IF(IR.EQ.1.OR.IR.EQ.NQ) GO TO 120                                 CDM16240
C                                                                       CDM16250
C          LID HAS NOT BEEN REACHED                                     CDM16260
C           TRAPEZOIDAL INTEGRATION APPLIED                             CDM16270
C                                                                       CDM16280
      DO 110 JI=1,2                                                     CDM16290
  110    C(JI)=C(JI)+(Q(IR,JI)*S*(DVLR+DVLRI))/DECAY(JI)                CDM16300
      GO TO 140                                                         CDM16310
C          TRAPEZOIDAL INTEGRATION APPLIED                              CDM16320
  120 DO 130 JK=1,2                                                     CDM16330
  130    C(JK)=C(JK)+(Q(IR,JK)*S*DVLR)/DECAY(JK)                        CDM16340
  140 IR=IR+1                                                           CDM16350
C          LOOPS TO RHO(MAX)                                            CDM16360
      IF(IR.LE.NQ) GO TO 10                                             CDM16370
C                                                                       CDM16380
C          STORE CONCENTRATION ACCORDING TO WIND DIRECTION SECTOR       CDM16390
C                                                                       CDM16400
  150 X=Y*YCON*F(IS,IU,K)                                               CDM16410
      DO 160 JL=1,2                                                     CDM16420
         AROSE(K,JL)=AROSE(K,JL)+C(JL)*X                                CDM16430
         APAR(JL,IS) = APAR(JL,IS) + C(JL)*X                            CDM16440
  160    ABAR(JL)=ABAR(JL)+C(JL)*X                                      CDM16450
  170 CONTINUE                                                          CDM16460
      RETURN                                                            CDM16470
      END                                                               CDM16480
C                                                                       CDM16490
C***********************************************************************CDM16500
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C
      SUBROUTINE POINT
C           SUBROUTINE POINT     (VERSION 85293), PART OF CDM-2.0.
C
C         THIS SUBROUTINE CALCULATES THE SECTOR CONCENTRATION FROM
C          POINT SOURCES.
C
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)
      DIMENSION S(2)
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,
     *              PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF
C
C         INITIALIZE POINT SOURCE COUNTER.
C          IP LOOPS TO IPS (NUMBER OF POINT SOURCES)
      IP=1
C
C         FIND UPWIND (XP) AND CROSSWIND (YP) DISTANCES FROM RECEPTOR
C          TO SOURCE
C
   10 VX=PX(IP)-RI
      VY=PY(IP)-RJ
      XP=(VY*WA(K)+VX*WB(K))*RAT*CV
      IF(XP.LE.0.) GO TO 180
      YP=ABS((VY*WB(K)-VX*WA(K))*RAT*CV)
      TM=XP*TTAN
C
C         IF SOURCE MAKES NO CONTRIBUTION TO RECEPTOR, SKIP TO NEXT
C
      IF(YP.GT.TM) GO TO 180
      IF(PH(IP).GE.50.) GO TO 20
      IF(NP50.LE.0) GO TO 20
      SZI=50.-PH(IP)
      IF(SZI.GT.30.) SZI=30.
      GO TO 30
   20 SZI=0.
   30 Y=YD
C
C         BEGIN LOOP OVER STABILITY CLASS
C
      DO 170 IS=1,6
C         IS: CONTROLS STABILITY CLASS
      IF(IS.EQ.5) Y=YN
      IC=ICP(IS)
      WZ=(PH(IP)*0.1)**UE(IS)
      IF(SZI.LE.0.) GO TO 40
      CALL VIRTX(KHIGH,NPDH,IC,0.0,SZI,XS)
      GO TO 50
   40 XS=0.
   50 DIST=XP+XS
C
C         BEGIN LOOP OVER WIND SPEED CLASS
C
      DO 160 IU=1,6
C         IU: CONTOLS WIND SPEED CLASS
C          IF FREQUENCY IS ZERO, SKIP
      IF(F(IS,IU,K).LE.0.) GO TO 160
      WS=U(IU)*WZ
      DO 60 JA=1,2
        DF=WS*GA(JA)
   60   DECAY(JA)=EXP(XP/DF)
C
C         IF PR(IP) IS LESS THAN OR EQUAL TO ZERO COMPUTE PLUME RISE
C          ACCORDING TO BRIGGS.
C
      IF(PR(IP).LE.0.) GO TO 70
C
C         HOLLANDS EQN.
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C                                                                       CDM17260
      DH=PR(IP)/WS                                                      CDM17270
C         CALCULATE PLUME RISE                                          CDM17280
      IK = IC                                                           CDM17290
      IF(IK.GT.4) IK = IK - 1                                           CDM17300
      DH=DH*(1.4-0.1*IK)                                                CDM17310
      HP = PH(IP)                                                       CDM17320
      DHM = DH                                                          CDM17330
C         CALCULATE STACK DOWNWASH EFFECTS                              CDM17340
C                                                                       CDM17350
      CALL STDW(NSTDW,VS1(IP),D1(IP),FRN(IP),WS,HP,DHM)                 CDM17360
      PHDH = HP + DHM                                                   CDM17370
      GO TO 120                                                         CDM17380
C                                                                       CDM17390
C         CALCULATE BRIGGS PLUME RISE  (1969, 1971, AND 1975)           CDM17400
C                                                                       CDM17410
   70 KST = IC                                                          CDM17420
C         CALCULATE PLUME RISE AND DISTANCE TO FINAL RISE.              CDM17430
      CALL PLRISE(VS1(IP),T1(IP),D1(IP),BFLUX(IP),TOA,WS,KST,DISTF,DH)  CDM17440
      HP = PH(IP)                                                       CDM17450
      DHM = DH                                                          CDM17460
C         CALCULATE STACK DOWNWASH EFFECTS                              CDM17470
      CALL STDW(NSTDW,VS1(IP),D1(IP),FRN(IP),WS,HP,DHM)                 CDM17480
      PHDH = HP + DHM                                                   CDM17490
C         CONSIDER GRADUAL PLUME RISE IF RECEPTOR DOWNWIND DISTANCE IS  CDM17500
C         LESS THAN THE DISTANCE TO FINAL RISE                          CDM17510
      IF (DIST .GE. DISTF) GO TO 120                                    CDM17520
C         CONSIDER GRADUAL PLUME RISE IF THE GRADUAL PLUME RISE OPTION  CDM17530
C         IS TURNED ON AND/OR THE BUOYANCY-INDUCED DISPERSION OPTION ISCDM17540
C         TURNED ON                                                     CDM17550
      IF ((NGRAD .LE. 0) .AND. (NPDH .LE. 0)) GO TO 120                 CDM17560
C                                                                       CDM17570
C         CALCULATE GRADUAL PLUME RISE                                  CDM17580
C                                                                       CDM17590
      GDELH = (160. * BFLUX(IP)**0.333333 * DIST**0.666667)/WS          CDM17600
      IF (GDELH .LT. DHM) DHM = GDELH                                   CDM17610
C         MODIFY THE FINAL EFFECTIVE HEIGHT ONLY IF THE GRADUAL PLUME   CDM17620
C         RISE OPTION IS TURNED ON                                      CDM17630
      IF (NGRAD .GT. 0) PHDH = HP + DHM                                 CDM17640
C                                                                       CDM17650
  120 CONTINUE                                                          CDM17660
C                                                                       CDM17670
C   CHECK TO SEE IF PLUME IS ABOVE UNSTABLE OR NEUTRAL MIXING DEPTH     CDM17680
C                                                                       CDM17690
      IF(IC.LE.5) THEN                                                  CDM17700
      IF(PHDH.GT.HL(IS) ) GO TO 160                                     CDM17710
      END IF                                                            CDM17720
C                                                                       CDM17730
      CALL SIGMAZ(KHIGH,NPDH,IC,DIST,DHM,SZ)                            CDM17740
C                                                                       CDM17750
      HHH1=PHDH+RCEPTZ                                                  CDM17760
      HH21 = HHH1*HHH1                                                  CDM17770
      HHH2=PHDH-RCEPTZ                                                  CDM17780
      HH22 = HHH2*HHH2                                                  CDM17790
      PHDH=PHDH*PHDH                                                    CDM17800
C                                                                       CDM17810
C          FOR UNSTABLE AND NEUTRAL CONDITIONS (A - D2) SEE             CDM17820
C          IF THE VERTICAL DISPERSION PARAMETER IS GREATER THAN OR      CDM17830
C          EQUAL TO 0.8 X MIXING HEIGHT, COMPUTE CONCENTRATION BY A     CDM17840
C          BOX MODEL                                                    CDM17850
C                                                                       CDM17860
      IF(IC.LE.5) THEN                                                  CDM17870
      IF(SZ.GE.HX(IS)) GO TO 130                                        CDM17880
      END IF                                                            CDM17890
C                                                                       CDM17900
C         LID HAS NOT BEEN REACHED; COMPUTE CONCENTRATION BY GAUSSIAN   CDM17910
C          FORMULA.                                                     CDM17920
C                                                                       CDM17930
      B=-0.5*(PHDH/(SZ*SZ))                                             CDM17940
      IF(ABS(B).GT.60.) GO TO 160                                       CDM17950
      WW=WS*XP*SZ                                                       CDM17960
      S(1)=PS(IP,1)/WW                                                  CDM17970
      S(2)=PS(IP,2)/WW                                                  CDM17980
      B1 = -0.5*HH21/(SZ*SZ)                                            CDM17990
      B2 = -0.5*HH22/(SZ*SZ)                                            CDM18000
      WW = 0.5*(EXP(B1) + EXP(B2))
      S(1)=S(1)*WW
      S(2)=S(2)*WW
      GO TO 140
C
C         LID HAS BEEN REACHED, COMPUTE CONCENTRATION BY A BOX MODEL.
C
  130 WW=WS*XP*HL(IS)
      S(1)=PS(IP,3)/WW
      S(2)=PS(IP,4)/WW
C
C         STORE CONCENTRATION ACCORDING TO WIND DIRECTION SECTOR
C
  140 B=Y*YCON*F(IS,IU,K)
      DO 150 JB=1,2
         X=S(JB)*B/DECAY(JB)
         PROSE(K,JB)=PROSE(K,JB)+X
         PPAR(JB,IS) = PPAR(JB,IS) + X
  150    PBAR(JB)=PBAR(JB)+X
  160 CONTINUE
  170 CONTINUE
C
C         INCREMENT POINT SOURCE COUNTER
C
  180 IP=IP+1
C
C         LOOP UNTIL ALL POINT SOURCES EVALUATED
C
      IF(IP.LE.IPS) GO TO 10
      RETURN
      END
C
C*****************************************************************
C
      SUBROUTINE PLRISE(VS,TS,D,F,T,U,KST,DISTF,DELH)
C            SUBROUTINE PLRISE   (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:   VS    - STACK GAS VELOCITY (M/SEC)
C                  TS    - STACK GAS TEMPERATURE (KELVIN)
C                  D     - STACK INSIDE DIAMETER (METERS)
C                  F     - BUOYANCY FLUX (M**4/SEC**3)
C                  T     - AMBIENT AIR TEMPERATURE (KELVIN)
C                  U     - WIND SPEED AT STACK HEIGHT (M/SEC)
C                  KST   - STABILITY CLASS
C         OUTPUT:  DISTF - DISTANCE TO FINAL RISE (METERS)
C                  DELH  - PLUME RISE (METERS)
C
C       CALLING ROUTINE:
C         POINT
C
C       DESCRIPTION:
C         THIS SUBROUTINE CALCULATES PLUME RISE ACCORDING TO METHODS BY
C         BRIGGS (1969, 1971, AND 1975)
C
      G = 9.80616
C
C         CALCULATE UNSTABLE-NEUTRAL MOMENTUM RISE REGARDLESS OF
C          STABILITY
C
      DELHM = 3.0 * VS * D/U
      IF (KST .GT. 5) GO TO 100
C
C         PLUME RISE FOR UNSTABLE-NEUTRAL CONDITIONS
C
      IF (TS .LT. T) GO TO 200
      IF (F .GE. 55.) GO TO 50
C         COMBINATION OF BRIGGS' (1971) EQS. 6&7, PAGE 1031, FOR F < 55
      DELH = (21.425 * F**0.75)/U
      IF (DELHM .GT. DELH) GO TO 200
      DISTF = 49. * F**0.625
      GO TO 999
C         COMBIMATION OF BRIGGS' (1971) EQS. 6&7, PAGE 1031, FOR F >= 5
   50 DELH = (38.71 * F**0.6)/U
      IF (DELHM .GT. DELH) GO TO 200
      DISTF = 119. * F**0.4
      GO TO 999
C
C         PLUME RISE FOR STABLE CONDITIONS
C
  100 DTHDZ = 0.02
      IF (KST .GT. 6) DTHDZ = 0.035
      S = G * DTHDZ/T
C         CALCULATE STABLE MOMENTUM RISE (BRIGGS' (1969) EQ. 4.28,
C          PAGE 59)
      DHA = 1.5 * (VS*VS * D*D * T/(4. * TS * U))**0.333333/S**0.166667
      IF (DHA .LT. DELHM) DELHM = DHA
      IF (TS .LT. T) GO TO 200
C         CALCULATE STABLE BUOYANCY RISE (WITH WIND)
      DELH = 2.6 * (F/(U * S))**0.333333
C         CALCULATE STABLE BUOYANCY RISE (CALM)
      DELHC = 4.0 * F**0.25 / S**0.375
      IF (DELHC .LT. DELH) DELH = DELHC
      IF (DELHM .GT. DELH) GO TO 200
      DISTF = 2.0715 * U/SQRT(S)
      GO TO 999
C
C         CASE WHERE MOMENTUM RISE DOMINATES OR IS GREATER THAN
C          BUOYANCY RISE
C
  200 DELH = DELHM
      DISTF = 0.0
C
  999 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE STDW(NSTDW,VS,D,FR,U,H,DELH)
C             SUBROUTINE STDW     (VERSION 85293), PART OF CDM-2.0.
C
C       PARAMETER LIST:
C         INPUT:  NSTDW - STACK DOWNWASH OPTION
C                 VS    - STACK GAS EXIT VELOCITY (M/SEC)
C                 D     - STACK INSIDE DIAMETER (METERS)
C                 FR    - FROUDE NUMBER
C                 U     - WIND SPEED AT STACK HEIGHT (M/SEC)
C         I/O:    H     - MODIFIED PHYSICAL STACK HEIGHT (METERS)
C                 DELH  - MODIFIED PLUME RISE (METERS)
C
C         CALLING ROUTINE:
C           POINT
C
C         DESCRIPTION:
C           THIS SUBROUTINE CALCULATES STACK DOWNWASH EFFECTS.
C           IF NSTDW < 0, THEN STACK DOWNWASH CALCULATED ACCORDING TO
C                         BJORKLUND AND BOWERS (1982).
C           IF NSTDW = 0, THEN STACK DOWNWASH NOT CONSIDERED.
C           IF NSTDW > 0, THEN STACK DOWNWASH CALCULATED ACCORDING TO
C                         BRIGGS (1973).
C
      IF (NSTDW) 100,999,200
C
C         CALCULATE STACK DOWNWASH ACCORDING TO BJORKLUND AND
C          BOWERS (1982)
C
  100 IF (FR .LT. 3.0) GO TO 110
         F = (3.*VS - 3.*U)/VS
         IF (F .GT. 1.0) F = 1.0
         IF (F .LT. 0.0) F = 0.0
         GO TO 120
  110 CONTINUE
         F = 1.0
  120 CONTINUE
      DELH = F * DELH
      GO TO 999
C
C         CALCULATE STACK DOWNWASH ACCORDING TO BRIGGS (1973)
C
  200 IF (VS/U .GE. 1.5) GO TO 210
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```
         H = H + 2 * D * (VS/U - 1.5)
         IF (H .LT. 0.0) H = 0.0
  210 CONTINUE
C
  999 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE VIRTX(KTYPE,KEY,KST,DH,GSZ,EX)
C            SUBROUTINE VIRTX     (VERSION 85293), PART OF CDM-2.0.
C
C          THIS SUBROUTINE COMPUTES THE VIRTUAL DISTANCE,
C           IN METERS, USING SUBROUTINE SIGMAZ.
C           THE ROUTINE IS BASICALLY A NEWTON RELAXATION SCHEME
C
      XMAX = 100.0*1000.0
      IF(KTYPE.NE.4) GO TO 10
      IF(KST.LE.4) GO TO 10
      IF(GSZ.LT.50.0) GO TO 10
      GO TO 70
   10 CONTINUE
      X = 1.0
   20 CALL SIGMAZ(KTYPE,KEY,KST,X,DH,SZ)
      IF(SZ.GT.GSZ) GO TO 30
      IF(X.GT.XMAX) GO TO 30
      X = 2.0*X
      GO TO 20
   30 IF(X.LE.1.0) GO TO 70
      IF(X.GE.XMAX.AND.SZ.LT.GSZ) GO TO 60
      X = 0.5*X
      STEP = 0.25*X
   40 CALL SIGMAZ(KTYPE,KEY,KST,X,DH,SZ)
      IF(SZ.GT.GSZ) GO TO 50
      X = X + STEP
      GO TO 40
   50 IF(STEP.LT.0.40) GO TO 70
      X = X - STEP
      STEP = 0.25*STEP
      GO TO 40
   60 EX = XMAX
      GO TO 80
   70 EX = X
   80 RETURN
      END
C
C***********************************************************************
C
      SUBROUTINE SIGMAZ(KTYPE,KEY,INKST,X,DH,SZ)
C            SUBROUTINE SIGMAZ     (VERSION 85293), PART OF CDM-2.0.
C
C          IN THIS SUBROUTINE WE COMPUTE THE VERTICAL DISPERSION USING
C           TWO BASIC FORMS.  THE BASIC FORMS USED TO COMPUTE SZ ARE AS
C           FOLLOWS:
C
C           FORM ONE. (BRIGGS, RURAL AND URBAN)
C              SZ = A*X/(1+B*X)**C
C
C           FORM TWO.  (BNL, KLUG, ST. LOUIS, PGCDM, AND PGSIG)
C              SZ = A*X**B
C
C          THE 7 VERTICAL DISPERSION SCHEMES ARE AS FOLLOWS:
C
C                  1    =  BRIGGS-RURAL, GIFFORD (1976)
C                  2    =  BRIGGS-URBAN, GIFFORD (1976)
C                  3    =  BNL, SINGER AND SMITH (1966)
C                  4    =  KLUG, VOGT (1977)
C                  5    =  ST. LOUIS, VOGT (1977)
C                  6    =  PGCDM, BUSSE & ZIMMERMAN (1973)
C                  7    =  PGSIG, PASQUILL (1961) AND GIFFORD (1960)
C
C-----------------------------------------------------------------------
C
C          TO ADD A DISPERSION SCHEME THE FOLLOWING MODIFICATIONS MUST
C           BE MADE TO THE CDM-2.0 SOURCE CODE:
```

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                                                                        CDM20260
C                                                                       CDM20270
C        IN SUBROUTINE SIGMAZ,                                          CDM20280
C          (1)  ADD STATEMENT LABEL TO COMPUTED GO TO                   CDM20290
C          (2)  INSERT THE FOLLOWING JUST BEFORE STATEMENT 190          CDM20300
C                 -  GO TO 190                                          CDM20310
C                 -  CODE FOR DISPERSION SCHEME                         CDM20320
C                                                                       CDM20330
C        IN BLOCK DATA,                                                 CDM20340
C          (1)  MODIFY DIMENSIONS OF ARRAY DISP(8, __)                  CDM20350
C          (2)  ADD DISPERSION SCHEME DESCRIPTION TO DATA STATEMENT     CDM20360
C               OF ARRAY DISP.  MAKE SURE THE DESCRIPTION DOES NOT      CDM20370
C               EXCEED 32 CHARACTERS.                                   CDM20380
C                                                                       CDM20390
C        IN SUBROUTINE CLINT,                                           CDM20400
C          (1)  MODIFY ERROR CHECK OF KLOW AFTER RECORD TYPE 5 IS       CDM20410
C               READ                                                    CDM20420
C          (2)  MODIFY UPPER RANGE LIMIT OF FORMAT STATEMENT 70.        CDM20430
C          (3)  MODIFY ERROR CHECK OF KHIGH AFTER RECORD TYPE 6 IS      CDM20440
C               READ                                                    CDM20450
C          (4)  MODIFY UPPER RANGE LIMIT OF FORMAT STATEMENT 110.       CDM20460
C                                                                       CDM20470
C-----------------------------------------------------------------------CDM20480
C                                                                       CDM20490
      DIMENSION A(7,5),B(7,5),C(7,5),G(7,6),XCAT(9,7),AA(10,7),BB(10,7)CDM20500
      DATA A/ 0.2000, 0.1200, 0.0800, 0.0600, 0.0600, 0.0300, 0.0160,   CDM20510
     *        0.2400, 0.2400, 0.2000, 0.1400, 0.1400, 0.0800, 0.0800,   CDM20520
     *        0.4000, 0.4000, 0.3300, 0.2200, 0.2200, 0.0600, 0.0600,   CDM20530
     *        0.0170, 0.0720, 0.0760, 0.1400, 0.1400, 0.2170, 0.2620,   CDM20540
     *        0.0790, 0.0790, 0.1310, 0.9100, 0.9100, 1.9300, 1.9300/   CDM20550
      DATA B/ 0.0000, 0.0000, 0.0002, 0.0015, 0.0015, 0.0003, 0.0003,   CDM20560
     *        0.0010, 0.0010, 0.0000, 0.0003, 0.0003, 0.0015, 0.0015,   CDM20570
     *        0.9100, 0.9100, 0.8600, 0.7800, 0.7800, 0.7100, 0.7100,   CDM20580
     *        1.3800, 1.0210, 0.8790, 0.7270, 0.7270, 0.6100, 0.5000,   CDM20590
     *        1.2000, 1.2000, 1.0460, 0.7020, 0.7020, 0.4650, 0.4650/   CDM20600
      DATA C/ 1.0000, 1.0000, 0.5000, 0.5000, 0.5000, 1.0000,  1.0000 ,CDM20610
     *       -0.5000,-0.5000, 1.0000, 0.5000, 0.5000, 0.5000,  0.5000 CDM20620
     *        21*0.0/                                                   CDM20630
      DATA G/2.539E-4,0.04936,0.1154,0.7368,0.7368,1.2969,1.5763,       CDM20640
     *      2.539E-4,0.04936,0.1014,0.2591,0.2591,0.2527,0.2017,        CDM20650
     *      0.0383,0.1393,0.1120,0.0856,0.0856,0.0818,0.0545,           CDM20660
     *      2.0886,1.1137,0.9109,0.5642,0.5642,0.4421,0.3606,           CDM20670
     *      2.0886,1.1137,0.9260,0.6869,0.6869,0.6341,0.6020,           CDM20680
     *      1.2812,0.9467,0.9100,0.8650,0.8650,0.8155,0.8124/           CDM20690
      DATA XCAT / 0.50, 0.40, 0.30, 0.25, 0.20, 0.15, 0.10, 0.00, 0.00,CDM20700
     *            0.40, 0.20, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,CDM20710
     *            0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,CDM20720
     *            0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,CDM20730
     *           30.00,10.00, 3.00, 1.00, 0.30, 0.00, 0.00, 0.00, 0.00,CDM20740
     *           40.00,20.00,10.00, 4.00, 2.00, 1.00, 0.30, 0.10, 0.00,CDM20750
     *           60.00,30.00,15.00, 7.00, 3.00, 2.00, 1.00, 0.70, 0.20/CDM20760
      DATA AA /453.85,346.75,258.89,217.41,179.52,170.22,158.08,122.80,CDM20770
     *           0.0,0.0,                                               CDM20780
     *         109.30,98.483,90.673,0.0,0.0,0.0,0.0,0.0,0.0,0.0,        CDM20790
     *         61.141,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,              CDM20800
     *         33.504,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,              CDM20810
     *         44.053,36.65,33.504,32.093,32.093,34.459,0.0,0.0,0.0,0.0CDM20820
     *         47.618,35.42,26.97,24.703,22.534,21.628,21.628,23.331,   CDM20830
     *           24.26,0.0,                                             CDM20840
     *         34.219,27.074,22.651,17.836,16.187,14.823,13.953,13.953,CDM20850
     *           14.457,15.209/                                         CDM20860
      DATA BB /2.1166,1.7283,1.4094,1.2644,1.1262,1.0932,1.0542,0.9447,CDM20870
     *           0.0,0.0,                                               CDM20880
     *         1.0971,0.98332,0.93198,0.0,0.0,0.0,0.0,0.0,0.0,0.0,      CDM20890
     *         0.91465,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,             CDM20900
     *         0.8098,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,              CDM20910
     *         0.51179,0.56589,0.60486,0.64403,0.81066,0.86974,0.0,0.0,CDM20920
     *           0.0,0.0,                                               CDM20930
     *         0.29592,0.37615,0.46713,0.50527,0.57154,0.63077,0.7566,  CDM20940
     *           0.81956,0.8366,0.0,                                    CDM20950
     *         0.21716,0.27436,0.32681,0.41507,0.4649,0.54503,0.63227,  CDM20960
     *           0.68465,0.78407,0.81558/                               CDM20970
C                                                                       CDM20980
      KST = INKST                                                       CDM20990
      IF(KST.GT.7) KST = 7                                              CDM21000
C
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      GO TO(20,20,30,40,40,50,70),KTYPE                                 CDM21010
C                                                                       CDM21020
C          BRIGGS RURAL AND URBAN, GIFFORD (1976)                       CDM21030
C                                                                       CDM21040
   20 Z1 = A(KST,KTYPE)                                                 CDM21050
      Z2 = B(KST,KTYPE)                                                 CDM21060
      Z3 = C(KST,KTYPE)                                                 CDM21070
      SZ = Z1*X/( 1.0+Z2*X)**Z3                                         CDM21080
      GO TO 190                                                         CDM21090
C                                                                       CDM21100
C          BNL, SINGER AND SMITH (1966)                                 CDM21110
C                                                                       CDM21120
   30 Z1 = A(KST,KTYPE)                                                 CDM21130
      Z2 = B(KST,KTYPE)                                                 CDM21140
      SZ = Z1*X**Z2                                                     CDM21150
      IF(KST.LE.4) GO TO 190                                            CDM21160
      IF(SZ.GT.50.0) SZ = 50.0                                          CDM21170
      GO TO 190                                                         CDM21180
C                                                                       CDM21190
C          KLUG, VOGT (1977); ST. LOUIS, VOGT (1977)                    CDM21200
C                                                                       CDM21210
   40 Z1 = A(KST,KTYPE)                                                 CDM21220
      Z2 = B(KST,KTYPE)                                                 CDM21230
      SZ = Z1*X**Z2                                                     CDM21240
      GO TO 190                                                         CDM21250
C                                                                       CDM21260
C          PGCDM, BUSSE & ZIMMERMAN (1973)                              CDM21270
C                                                                       CDM21280
   50 IC = KST                                                          CDM21290
      IZ = 1                                                            CDM21300
      IF(X.GE.5000.0) GO TO 60                                          CDM21310
      IZ = 2                                                            CDM21320
      IF(X.GE.500.0) GO TO 60                                           CDM21330
      IZ = 3                                                            CDM21340
   60 IB = IZ + 3                                                       CDM21350
      SZ = G(IC,IZ)*X**G(IC,IB)                                         CDM21360
      GO TO 190                                                         CDM21370
C                                                                       CDM21380
C          PGSIG, PASQUILL (1961) AND GIFFORD (1960)                    CDM21390
C                                                                       CDM21400
   70 X = X/1000.                                                       CDM21410
C          ARRAYS ARE DESIGNED FOR DISTANCE IN KILOMETERS               CDM21420
      DO 80 ID = 1,9                                                    CDM21430
        IF (X .GE. XCAT(ID,KST)) GO TO 90                               CDM21440
   80 CONTINUE                                                          CDM21450
      ID = 10                                                           CDM21460
   90 SZ = AA(ID,KST) * X ** BB(ID,KST)                                 CDM21470
      IF (SZ .GT. 5000.) SZ = 5000.                                     CDM21480
      X = X * 1000.                                                     CDM21490
C          CONVERT BACK TO METERS                                       CDM21500
C                                                                       CDM21510
  190 IF(KEY.LE.0) GO TO 200                                            CDM21520
      SZ = SQRT( SZ*SZ + (DH*DH)/(3.5*3.5))                             CDM21530
  200 RETURN                                                            CDM21540
      END                                                               CDM21550
C                                                                       CDM21560
C***********************************************************************CDM21570
C                                                                       CDM21580
      BLOCK DATA                                                        CDM21590
C                      BLOCK DATA     (VERSION 85293), PART OF CDM-2.0. CDM21600
      PARAMETER (NPTS=200,NQLIM=100,NASE=50,NASN=50)                    CDM21610
      COMMON /C1/ K,MX,MN,F(6,6,36),UBAR(6),U(6),RI,RJ,INC(4),DELR      CDM21620
      COMMON /C2/ UE(6),YD,YN,TMN,DINT,YCON,TA(4),IPG,XG,YG,IRD         CDM21630
      COMMON /C3/ IRUN,CA(2),CB(2),TK(36),AROS(2),PROS(2),TANG          CDM21640
      COMMON /C4/ DECAY(2),ICA(6),ICP(6),HL(6),HX(6),GB(2),NQ,IVER,IWR CDM21650
      COMMON /C5/ Q(NQLIM,4),GA(2),IAD(4,5),IAS,TDA,TDB,TDC,IPU         CDM21660
      COMMON /QCOM/ N,DR,IX,IY,TT(36,21),KTC,IXX,IYY,RAD,TD,            CDM21670
     *              Z(NASE,NASN,3)                                      CDM21680
      COMMON /ACOM/ PI,SZA(6),ABAR(2),AROSE(36,2),XS(6)                 CDM21690
      COMMON /PCOM/ PH(NPTS),PR(NPTS),PS(NPTS,4),PX(NPTS),PY(NPTS),     CDM21700
     *              WA(36),WB(36),PROSE(36,2),CV,IPS,RAT,PBAR(2),TOA,   CDM21710
     *              VS1(NPTS),T1(NPTS),D1(NPTS),FRN(NPTS),BFLUX(NPTS)   CDM21720
      COMMON /SET/ N1636,DELTA,TTAN,NP50,NPDH,NSTDW,NGRAD,KLOW,KHIGH,   CDM21730
     *             PPAR(2,6),APAR(2,6),WHA(6),FAC,RCEPTZ,KELVIN,NDEF    CDM21740
      COMMON /TITLE/ HEADNG(20),PNAME(2),D16(32),D36(72),DISP(8,7),     CDM21750
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*              TTITLE(3)                                          CDM21760
 DATA YCON/0.1E7/                                                 CDM21770
 DATA INC,IPG,IPS,IX,IY/1,2,4,4,70,0,1,1/                         CDM21780
 DATA IXX,IYY,IAS/1,1,0/,TD/0.1E-3/                               CDM21790
 DATA RAD,PI/57.2958,0.797885/                                    CDM21800
 DATA IAD/0,0,1,1,0,1,0,1,4*0,4*1,0,1,1,0/                        CDM21810
 DATA IVER/85293/                                                 CDM21820
 DATA D16/' N  ','    ',' NNE','    ',' NE ','    ',' ENE','    ',CDM21830
*         ' E  ','    ',' ESE','    ',' SE ','    ',' SSE','    ',CDM21840
*         ' S  ','    ',' SSW','    ',' SW ','    ',' WSW','    ',CDM21850
*         ' W  ','    ',' WNW','    ',' NW ','    ',' NNW','    '/CDM21860
 DATA D36/'000-','010 ','010-','020 ','020-','030 ','030-','040 ',CDM21870
*         '040-','050 ','050-','060 ','060-','070 ','070-','080 ',CDM21880
*         '080-','090 ','090-','100 ','100-','110 ','110-','120 ',CDM21890
*         '120-','130 ','130-','140 ','140-','150 ','150-','160 ',CDM21900
*         '160-','170 ','170-','180 ','180-','190 ','190-','200 ',CDM21910
*         '200-','210 ','210-','220 ','220-','230 ','230-','240 ',CDM21920
*         '240-','250 ','250-','260 ','260-','270 ','270-','280 ',CDM21930
*         '280-','290 ','290-','300 ','300-','310 ','310-','320 ',CDM21940
*         '320-','330 ','330-','340 ','340-','350 ','350-','360 '/CDM21950
 DATA DISP/'BRIG','GS-R','URAL',', GI','FFOR','D (1','976)','    'CDM21960
*          'BRIG','GS-U','RBAN',', GI','FFOR','D (1','976)','    'CDM21970
*          'BNL,',' SIN','GER ','AND ','SMIT','H (1','966)','    'CDM21980
*          'KLUG',', VO','GT (','1977',')   ','    ','    ','    'CDM21990
*          'ST. ','LOUI','S, V','OGT ','(197','7)  ','    ','    'CDM22000
*          'PGCD','M, B','USSE',' & Z','IMME','RMAN',' (19','73) 'CDM22010
*          'PGSI','G, P','ASQU','ILL,','GIFF','ORD(','1961',',60)'CDM22020
 DATA TTITLE/' F) ',' C) ',' K) '/                                CDM22030
 END                                                              CDM22040
```

Date_______________

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I would like to receive future revisions to the "CDM-2.0 User's Guide."

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____

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